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Suzuki

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(54) **TWO-COMPONENT DEVELOPING DEVICE, IMAGE FORMING APPARATUS, AND STIRRING SCREW THEREOF**

(75) Inventor: **Eiji Suzuki**, Kawasaki (JP)

(73) Assignee: **Fuji Xerox Co., Ltd.**, Tokyo (JP)

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(51) **Int. Cl.**^{7} **G03G 15/08**
(52) **U.S. Cl.** **399/254**; 399/256
(58) **Field of Search** 399/254, 256, 399/255

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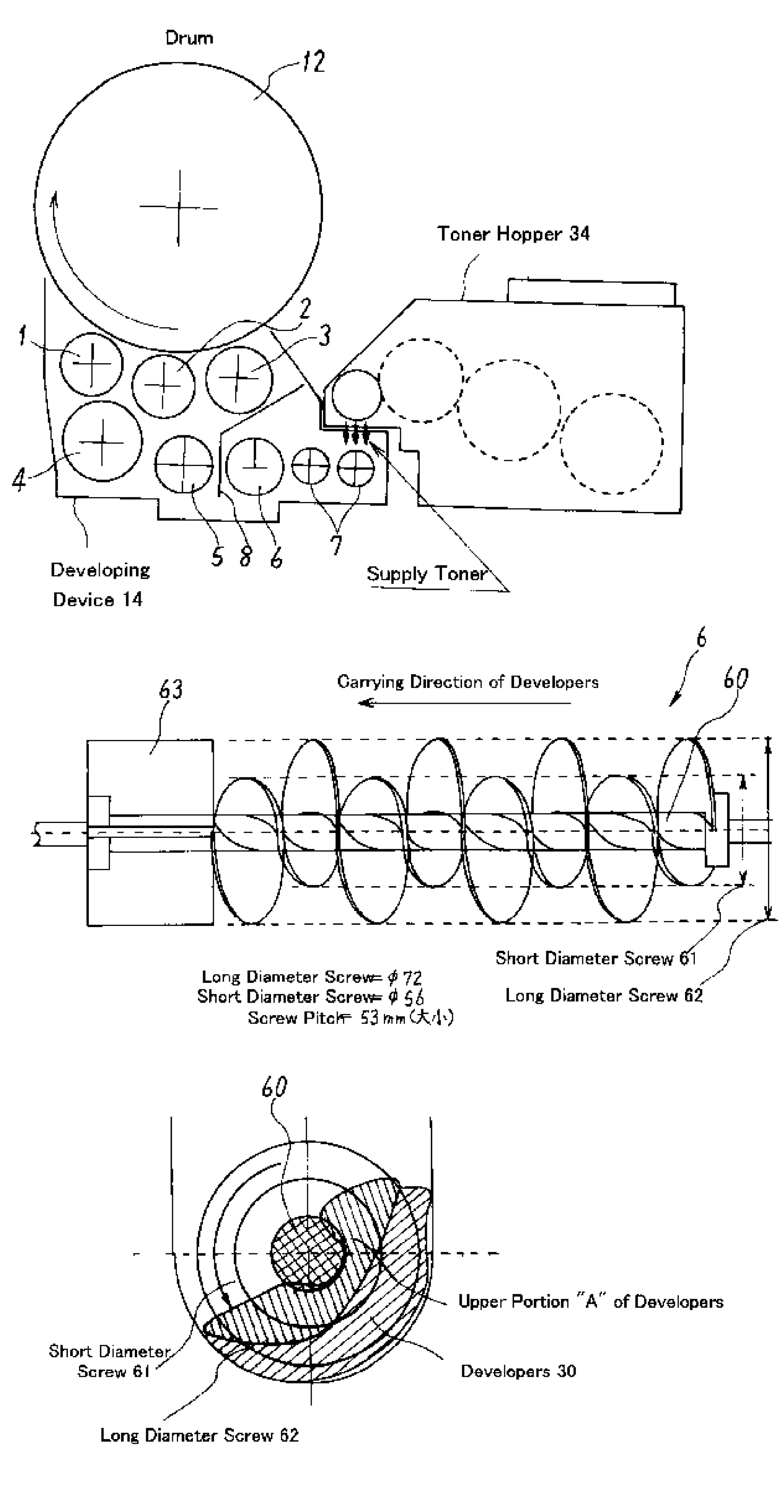
Primary Examiner—Fred L Braun
(74) *Attorney, Agent, or Firm*—Armstrong, Westerman & Hattori, LLP

(57) **ABSTRACT**

A two-component developing device to stir a developer with toners so as to fully and evenly stir the toners. The two-component developing device developer carrying members (**1** to **3**) for carrying the developer (**130**) containing carriers and toners, to a latent image carrier (**12**), a stirring and carrying screw (**6**) for stirring the toners with the developer. The stirring and carrying screw (**6**) includes a screw shaft, a spiral screw (**61**) with a relatively short diameter, and another spiral screw (**62**) with a relatively long diameter, which are alternately wound around the same screw shaft. By arranging the short-diameter spiral screw (**61**) as a member for stirring the surface layer of the developer, the developer can be fully stirred while being carried on the face of a blade thereof.

13 Claims, 16 Drawing Sheets



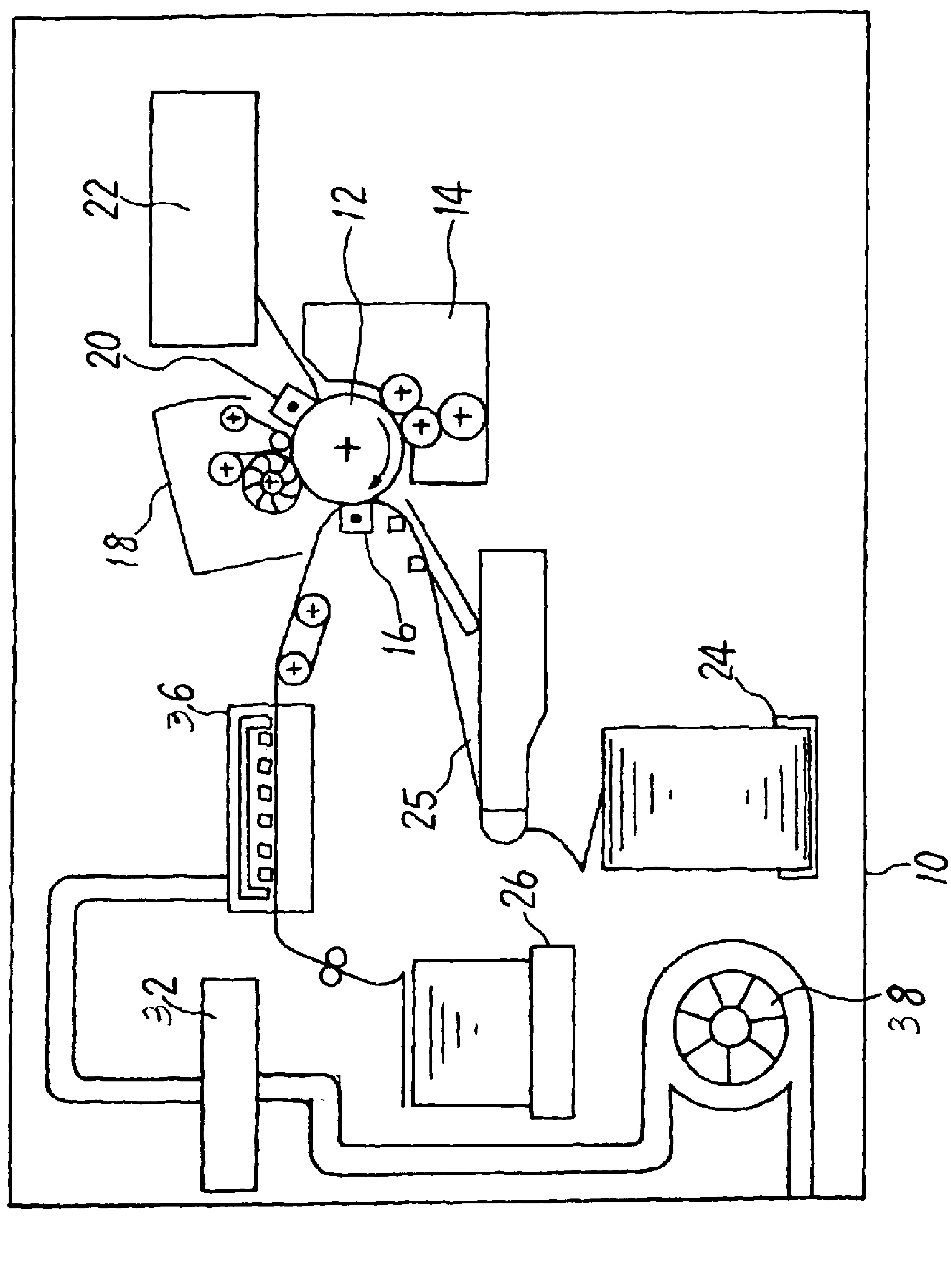
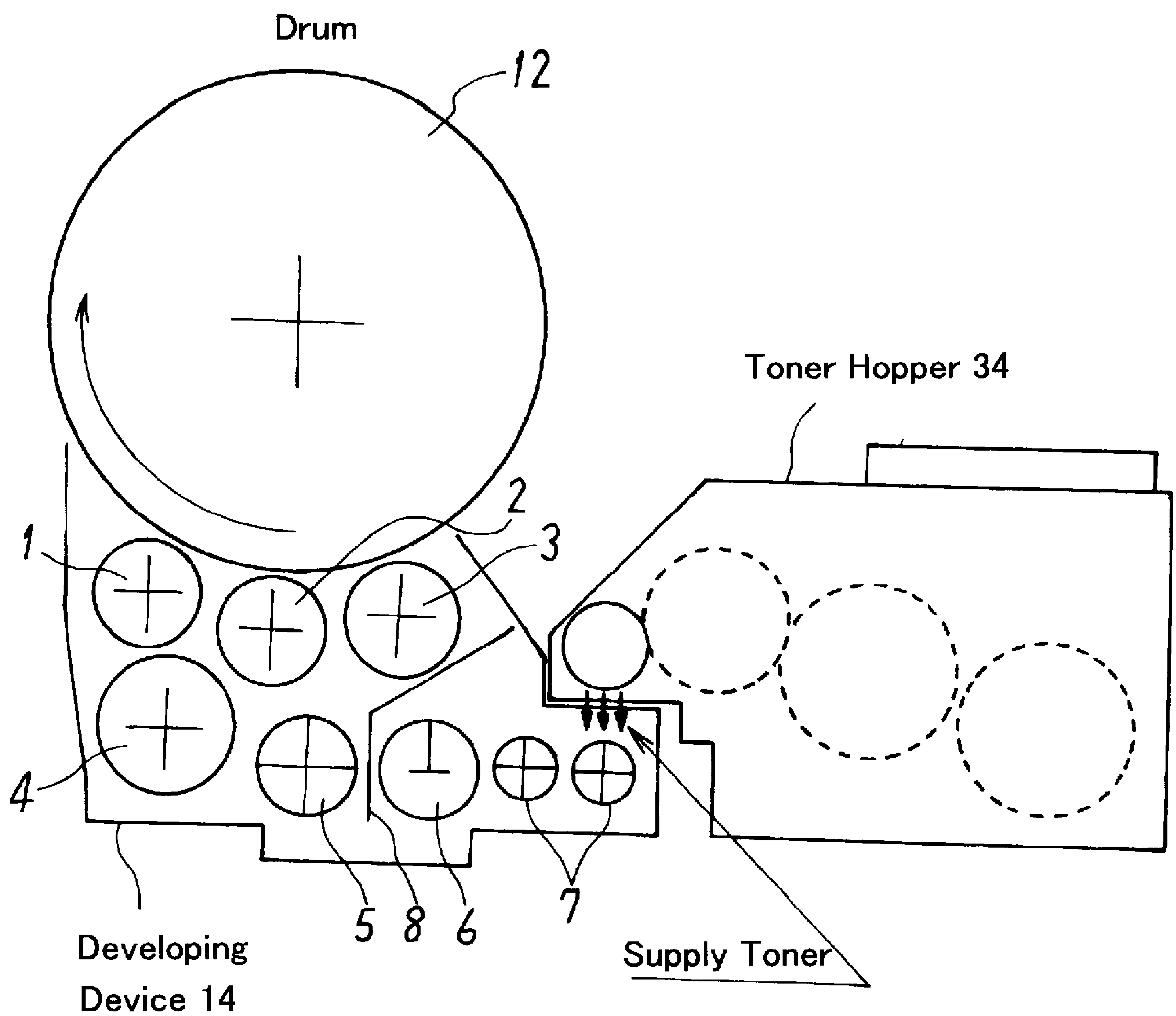


FIG. 1

FIG. 2



Drum
12
Toner Hopper 34
1
2
3
4
5
8
6
7
Developing
Device 14
Supply Toner

FIG. 3

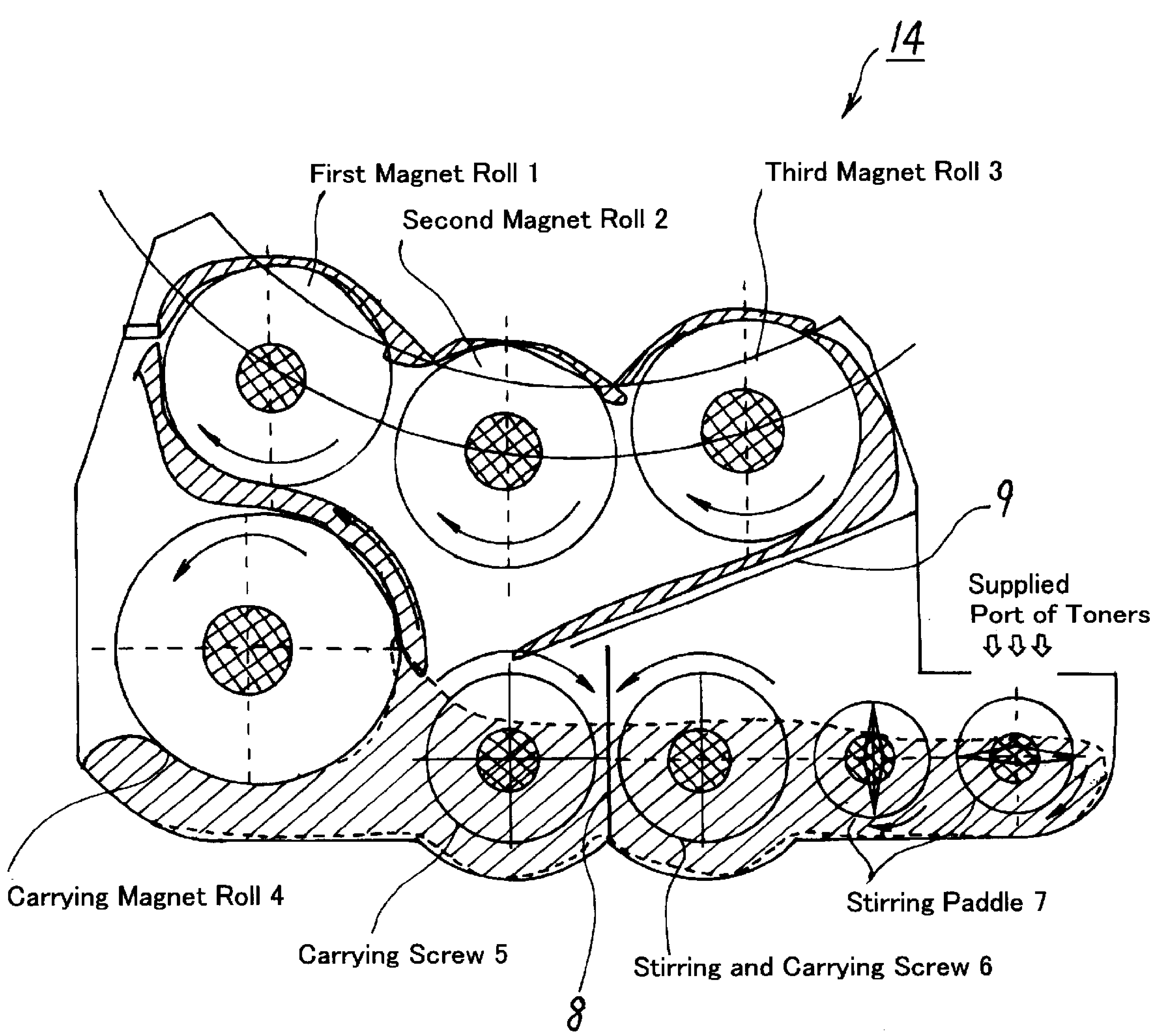

14
First Magnet Roll 1
Second Magnet Roll 2
Third Magnet Roll 3
9
Supplied
Port of Toners
Carrying Magnet Roll 4
Carrying Screw 5
8
Stirring and Carrying Screw 6
Stirring Paddle 7

FIG. 4

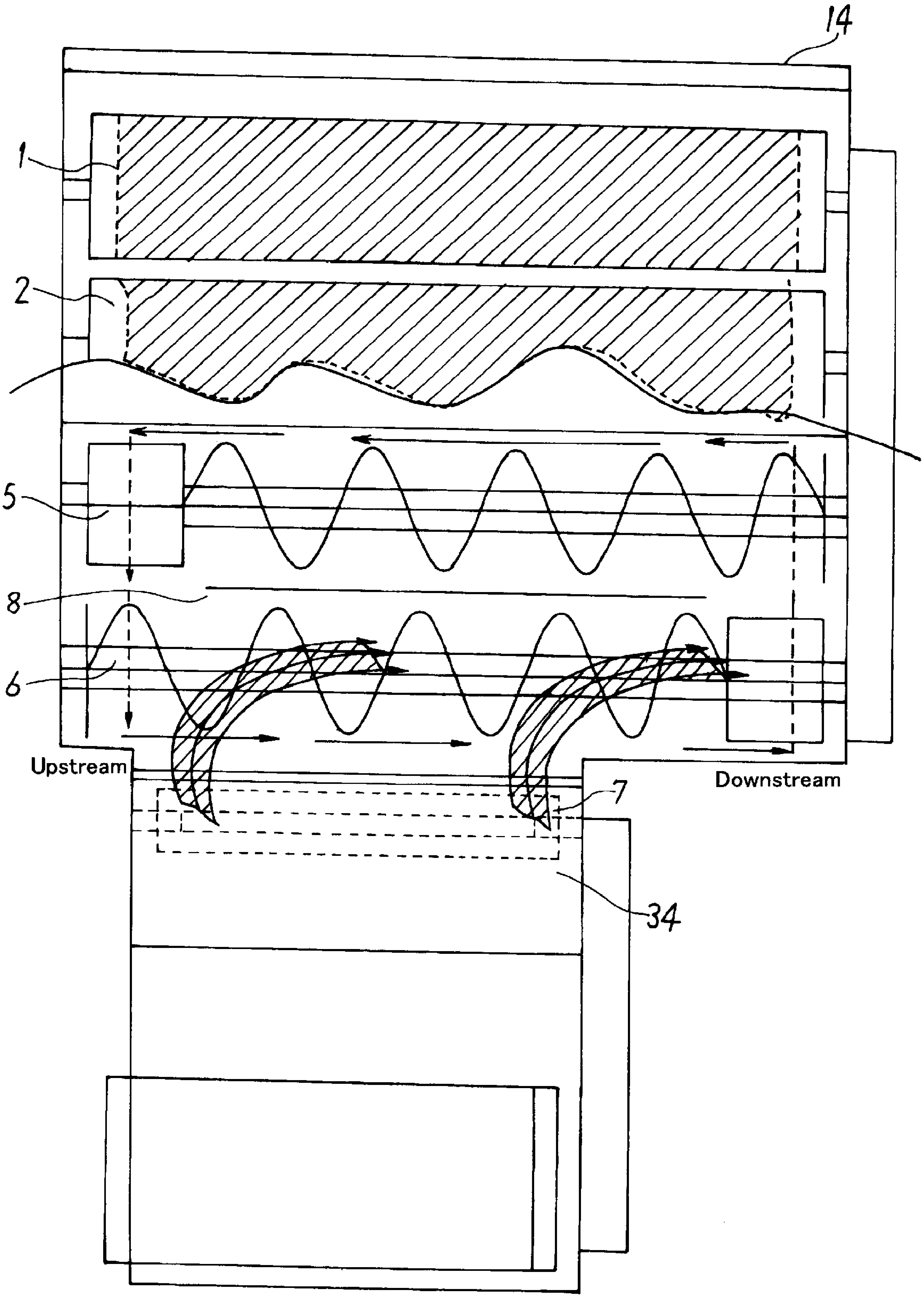


FIG. 5

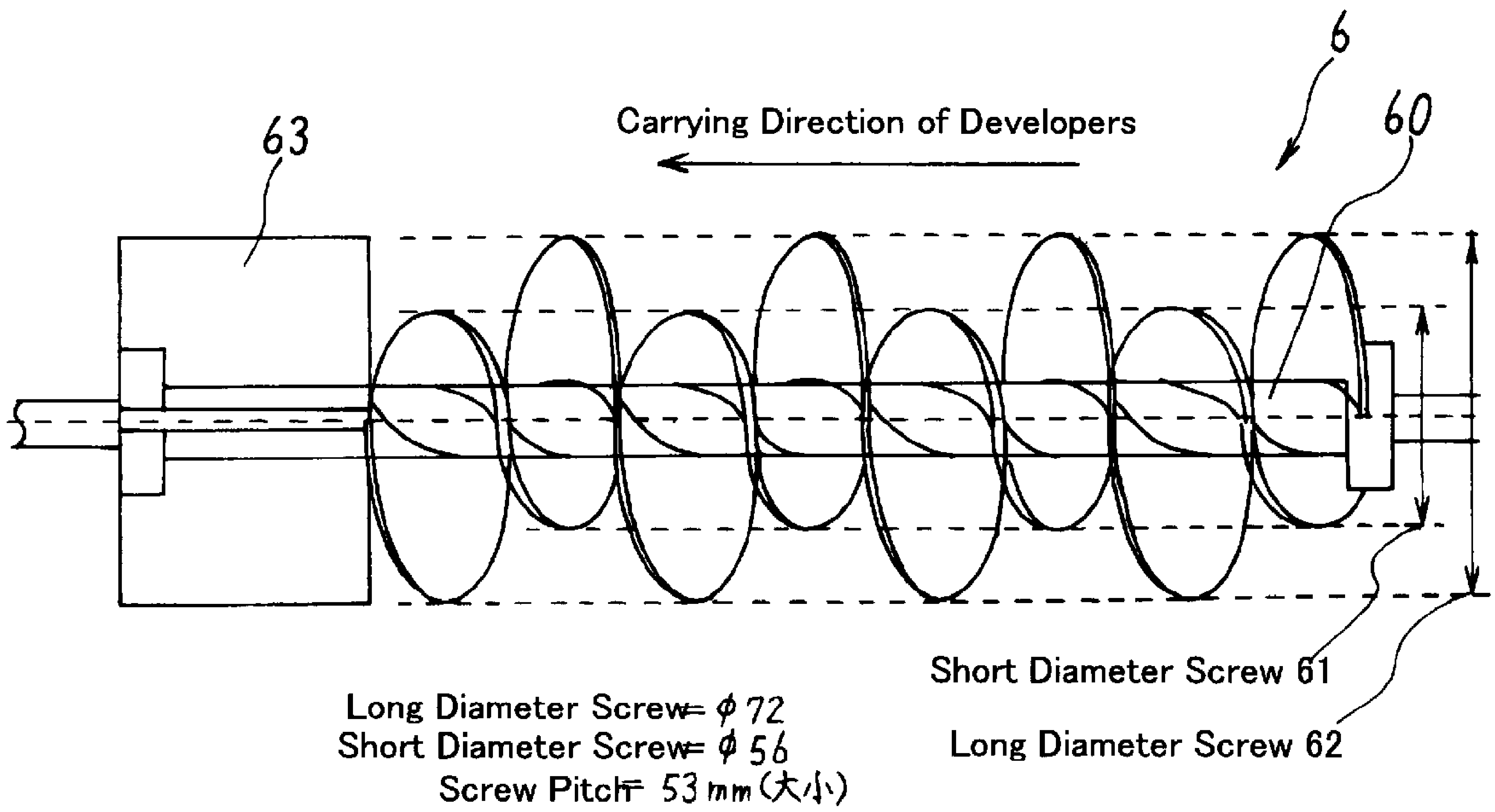

Carrying Direction of Developers
6
60
63
Short Diameter Screw 61
Long Diameter Screw 62
Long Diameter Screw= φ72
Short Diameter Screw= φ56
Screw Pitch= 53mm (大小)

FIG. 6

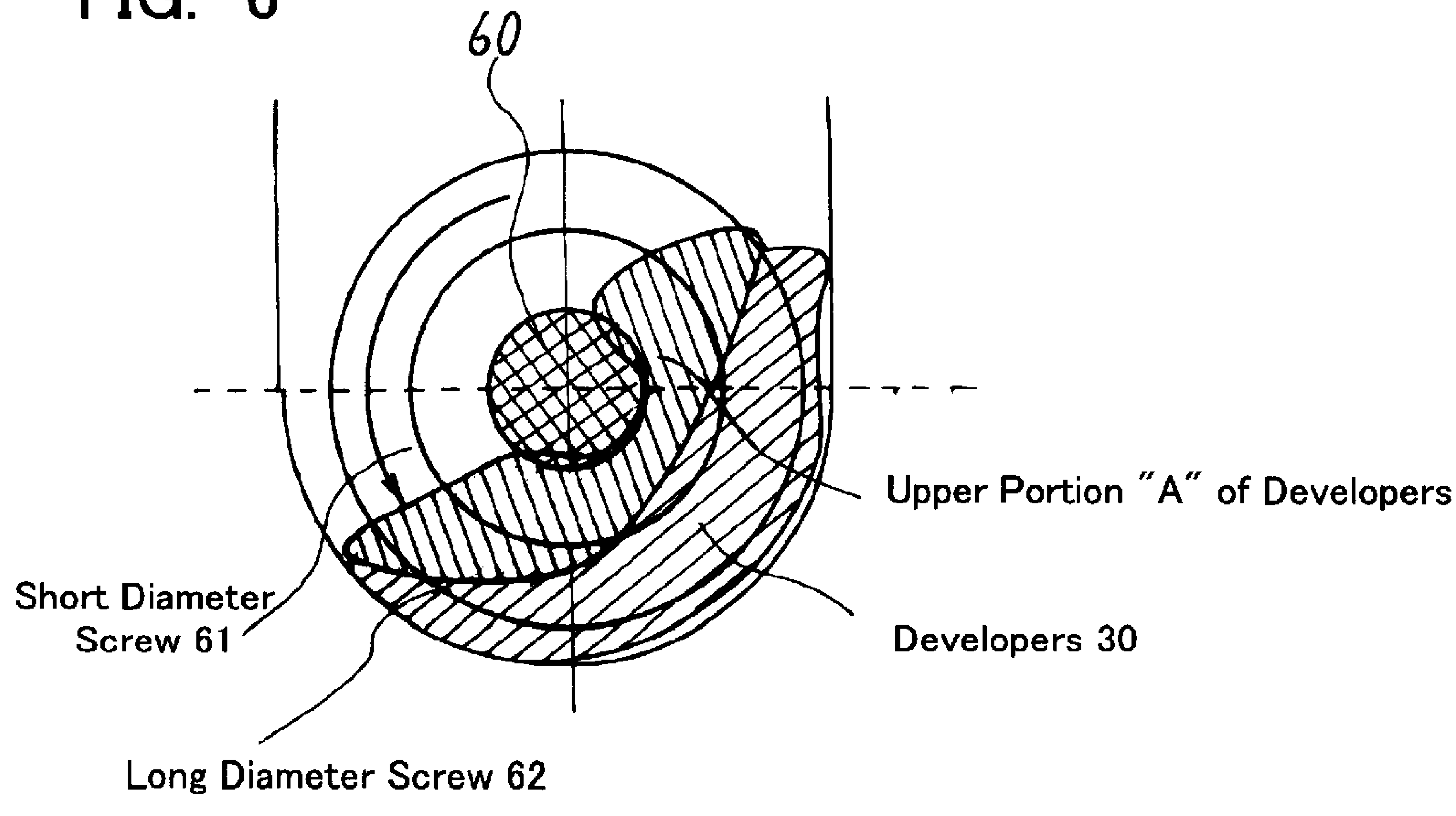

60
Upper Portion "A" of Developers
Developers 30
Short Diameter Screw 61
Long Diameter Screw 62

FIG. 7

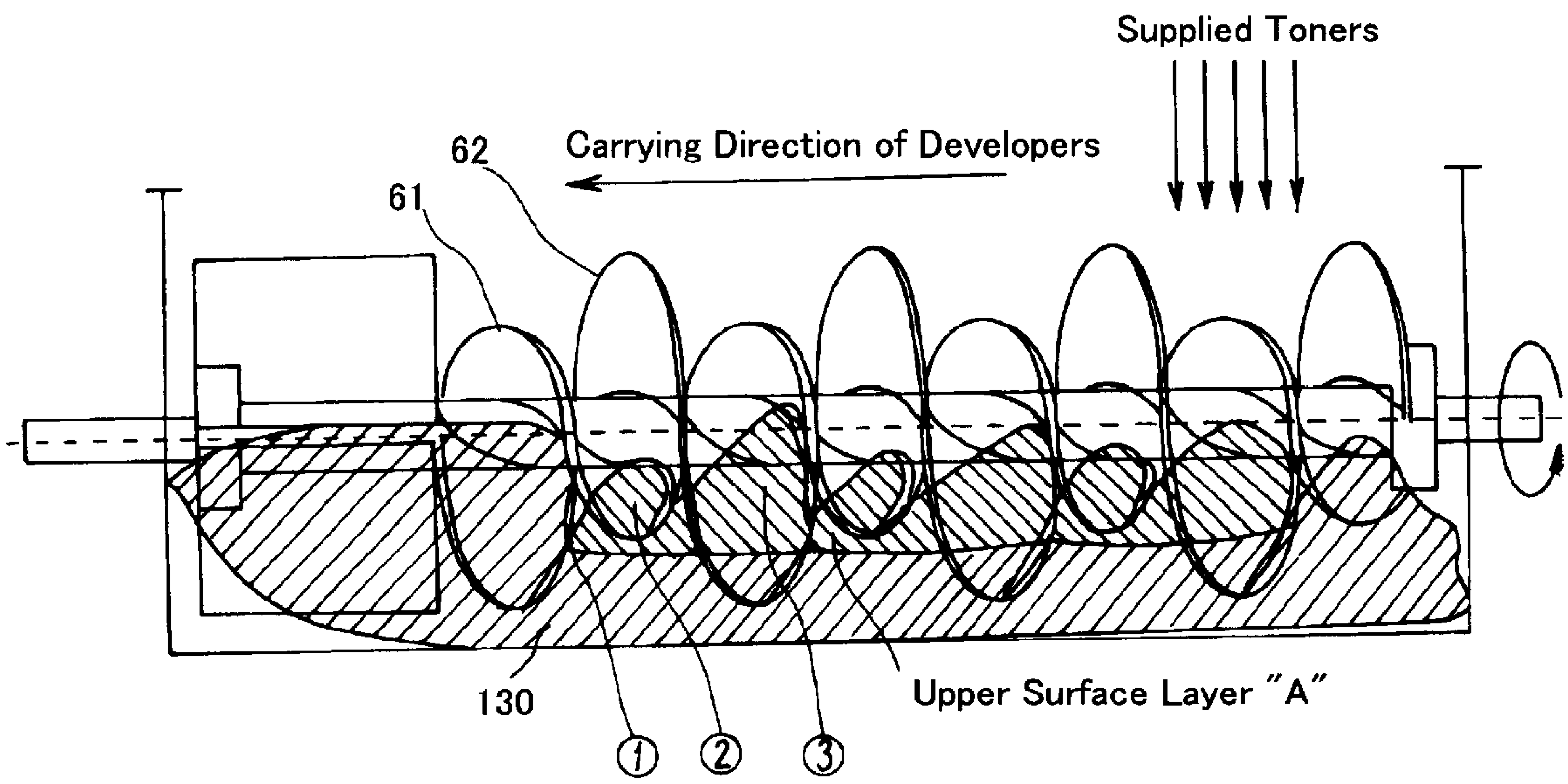

Supplied Toners
Carrying Direction of Developers
62
61
130
Upper Surface Layer "A"
①
②
③

FIG. 8

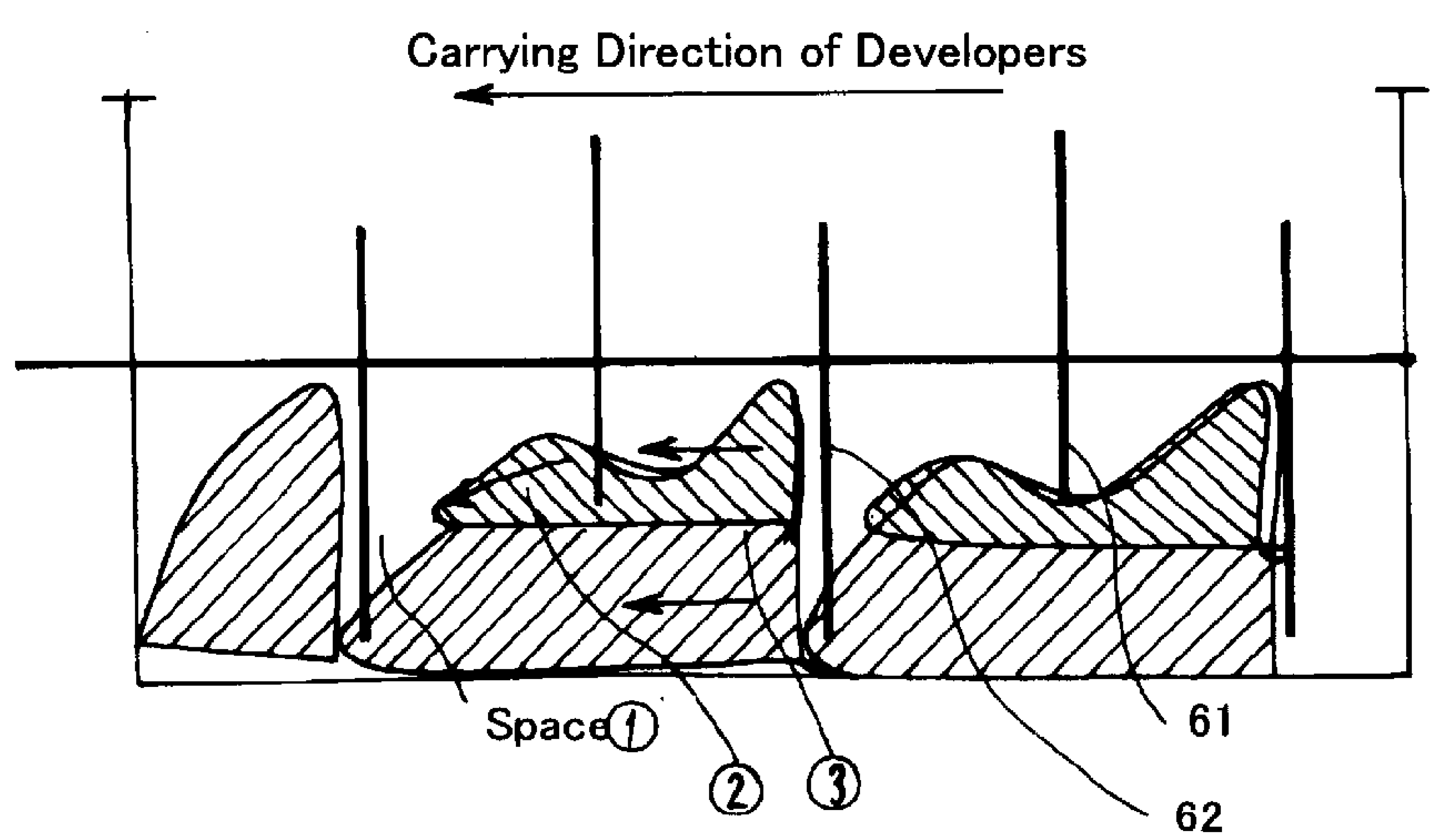
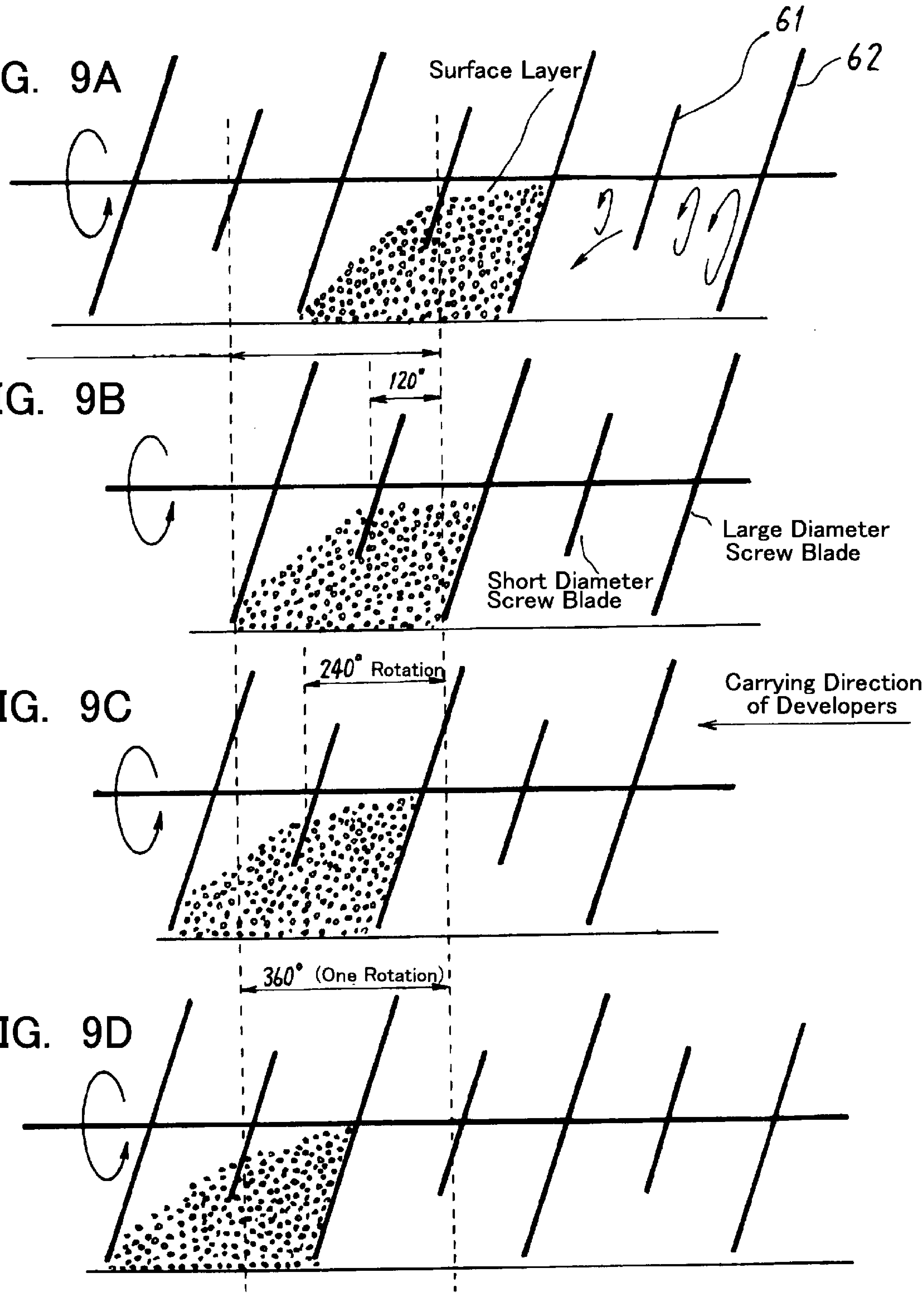

Carrying Direction of Developers
Space①
②
③
61
62

FIG. 9A

FIG. 9B

FIG. 9C

FIG. 9D



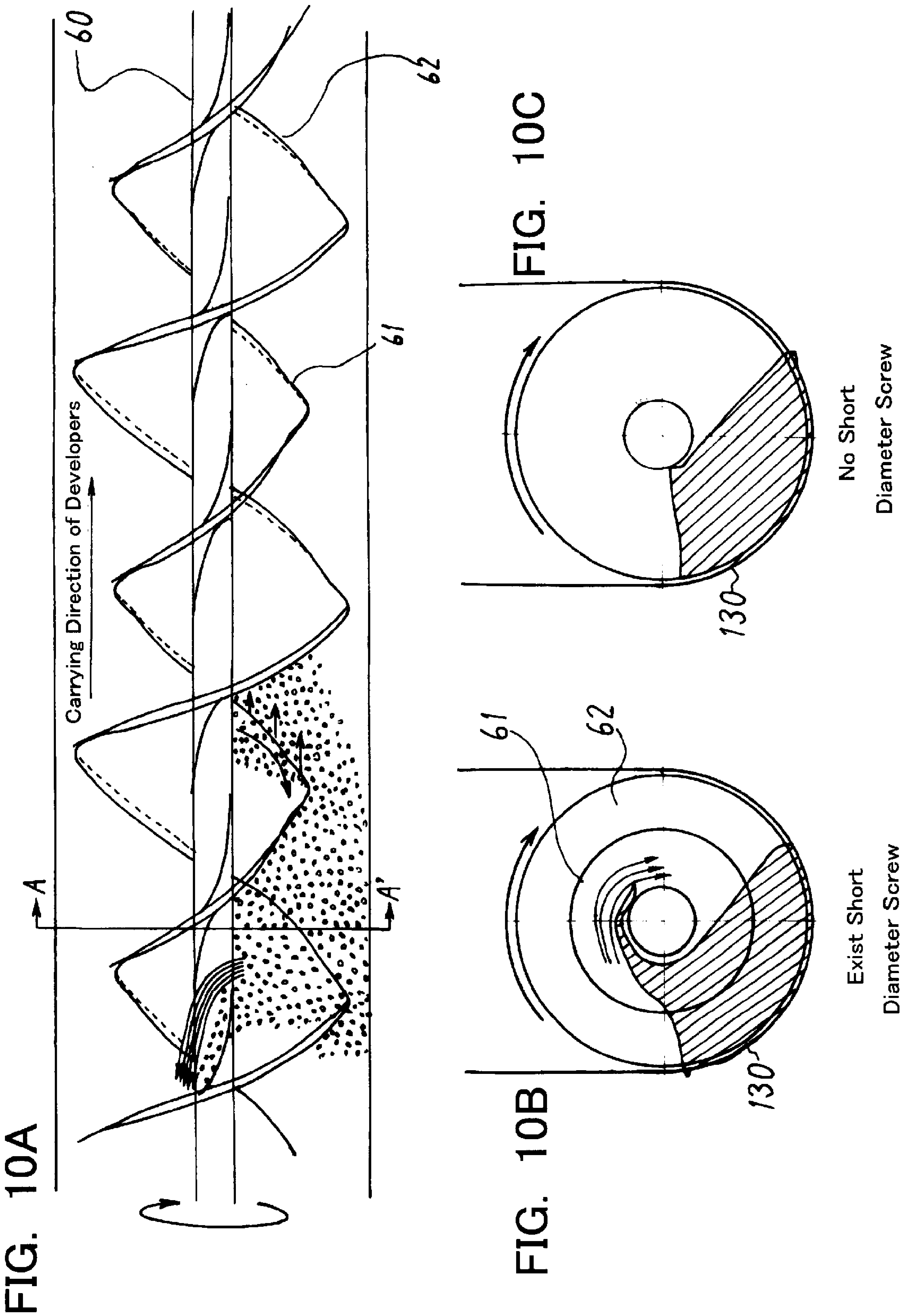


FIG. 10A

FIG. 10B

FIG. 10C

FIG. 11

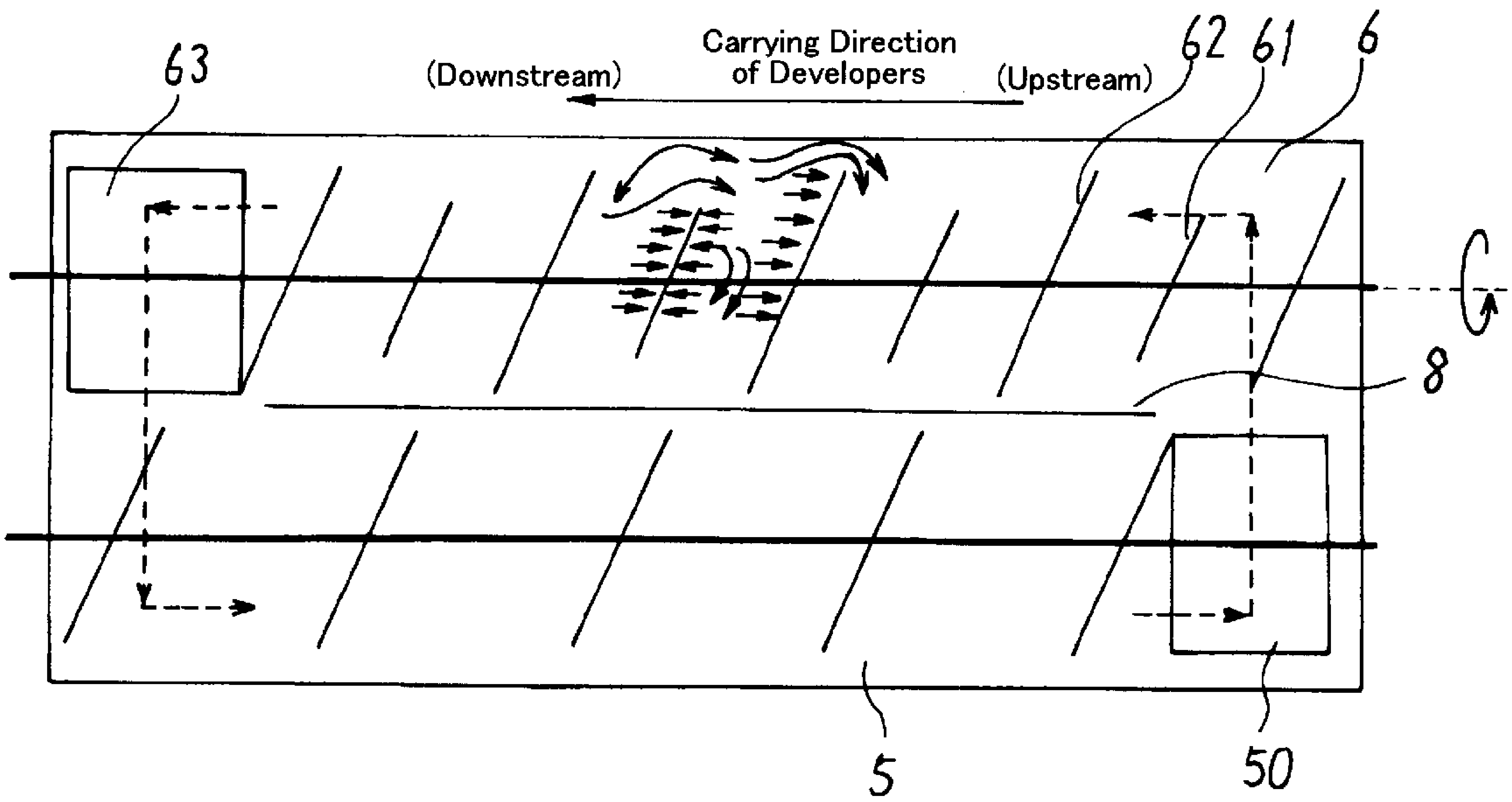

Carrying Direction
of Developers
(Downstream)
(Upstream)
63
62
61
6
8
5
50

FIG. 12

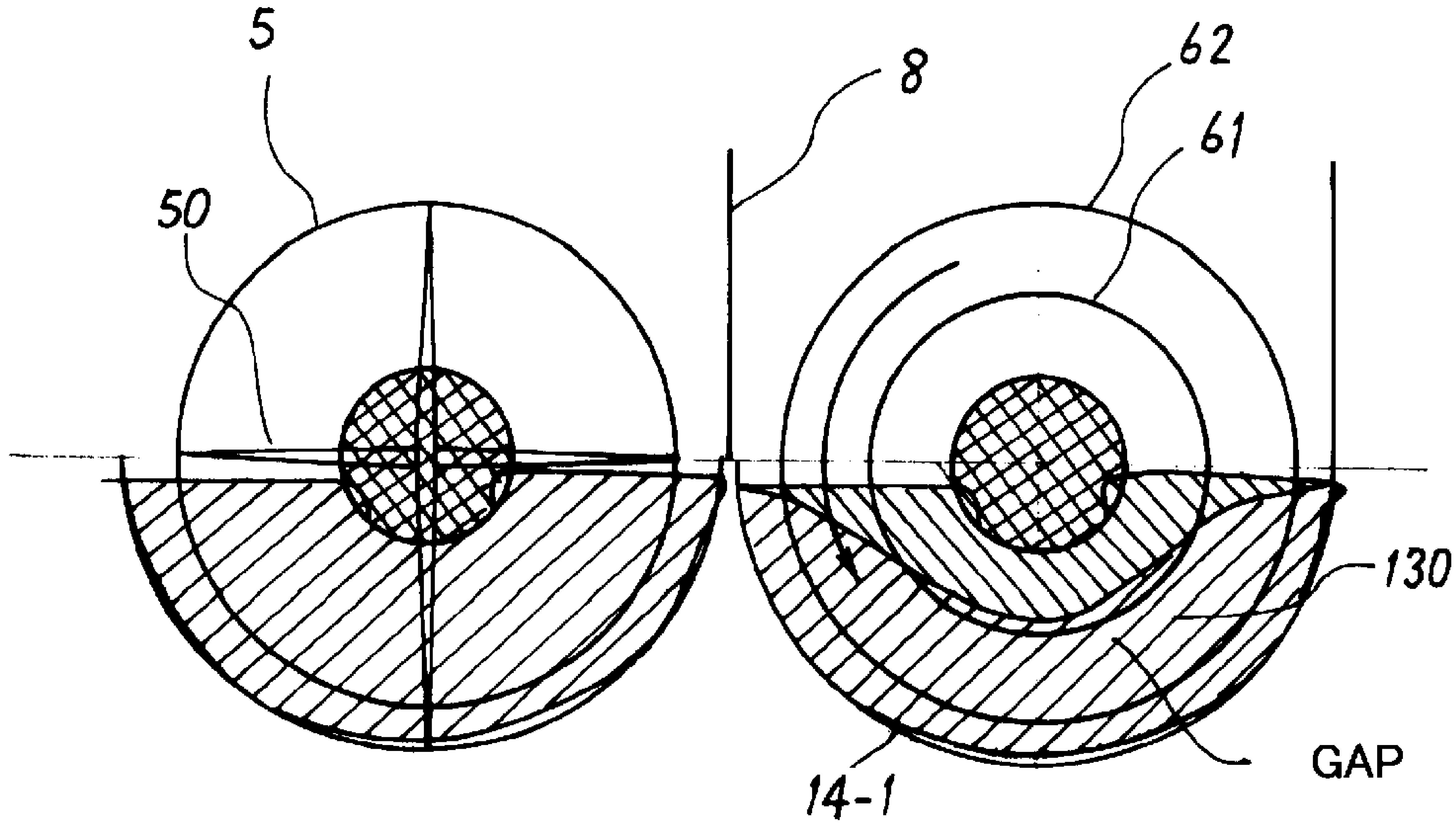

5
50
8
62
61
130
14-1
GAP

FIG. 13

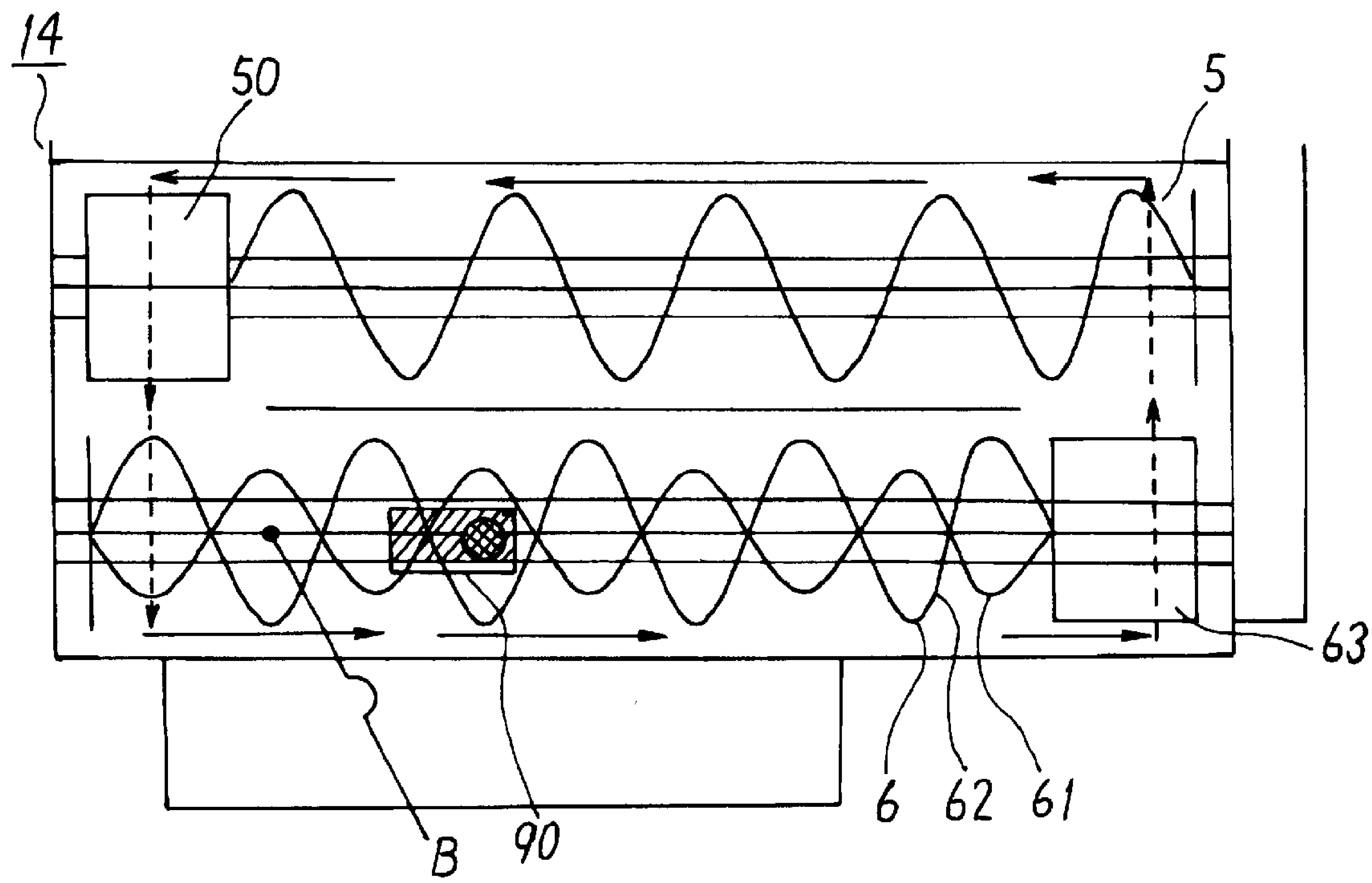

14
50
5
63
6
62
61
B
90

FIG. 14

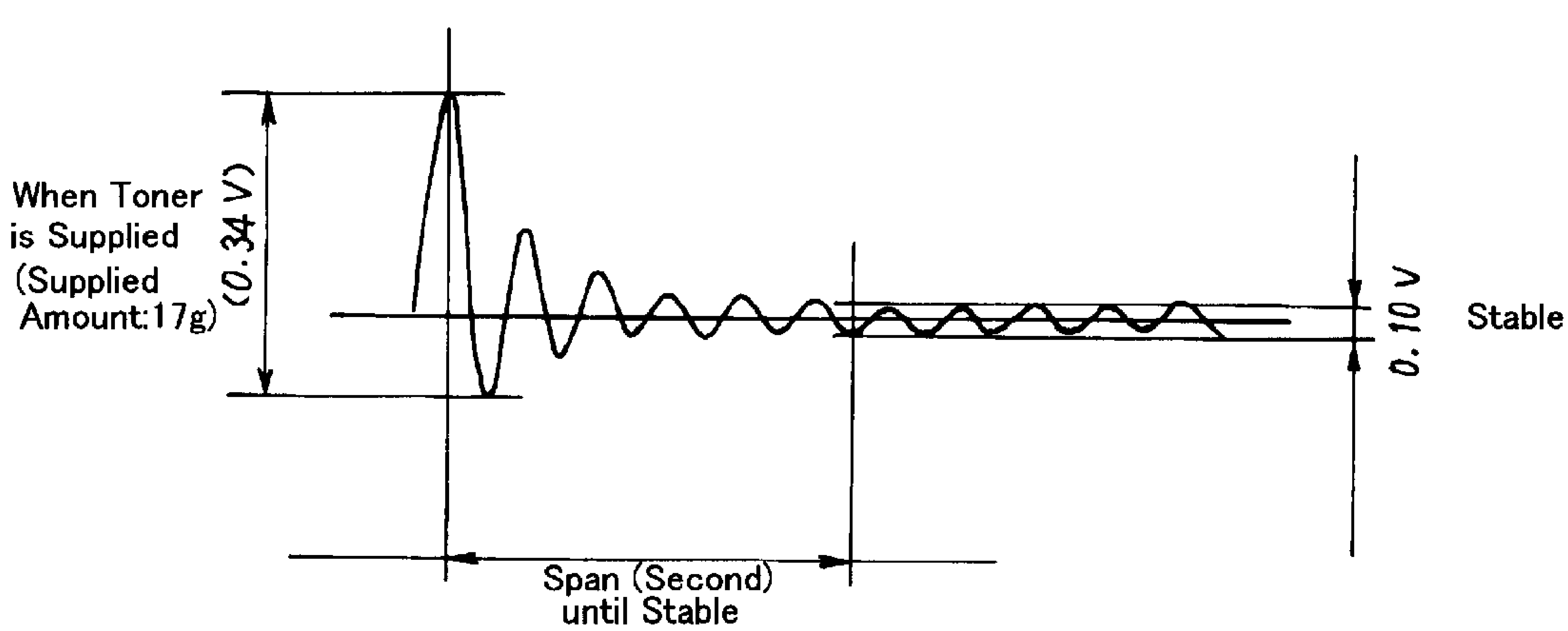

When Toner is Supplied (Supplied Amount:17g)
(0.34 V)
0.10 V
Stable
Span (Second) until Stable

FIG. 15

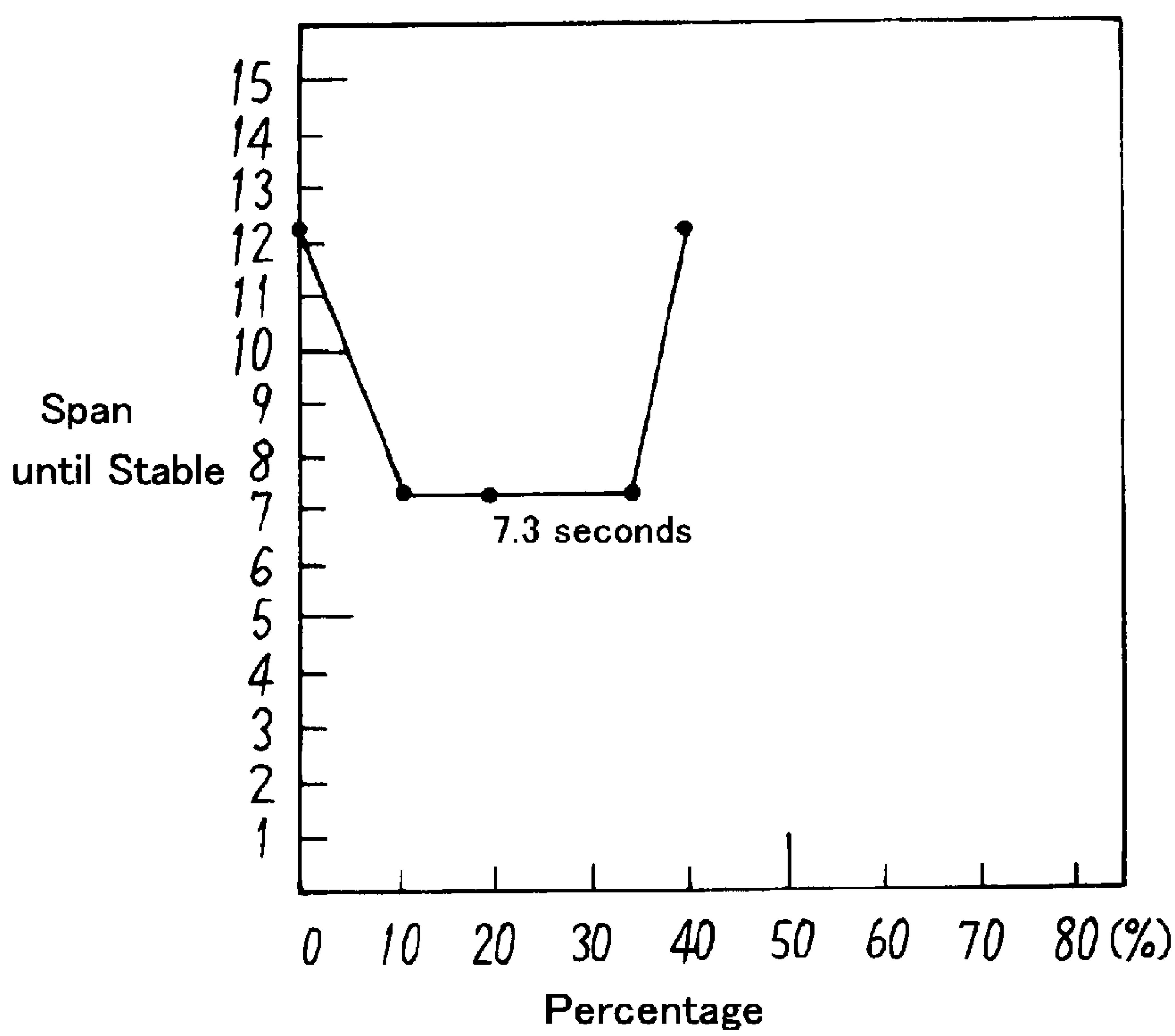

Span
until Stable
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
7.3 seconds
0 10 20 30 40 50 60 70 80 (%)
Percentage

FIG. 16

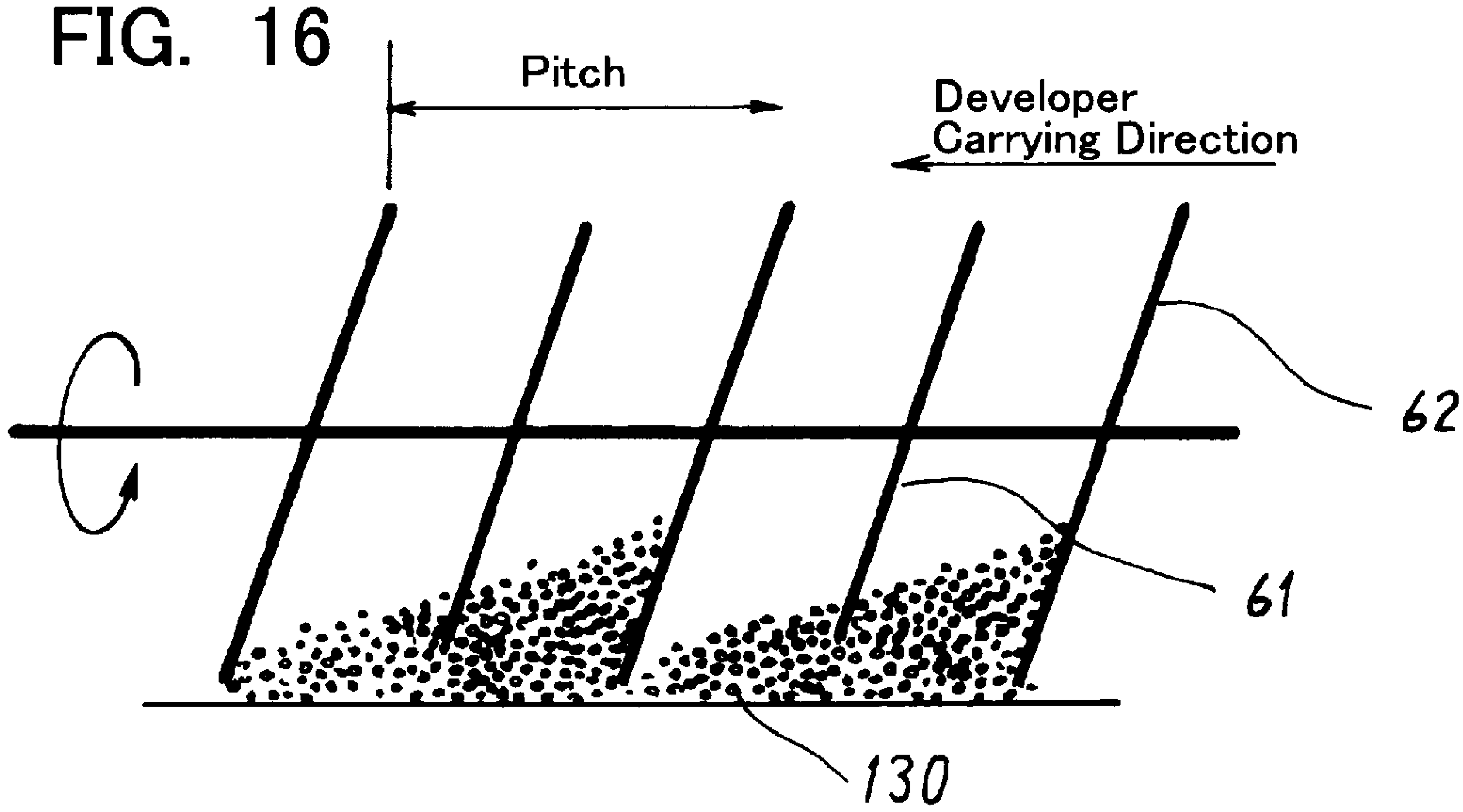

Pitch
Developer
Carrying Direction
62
61
130

FIG. 17

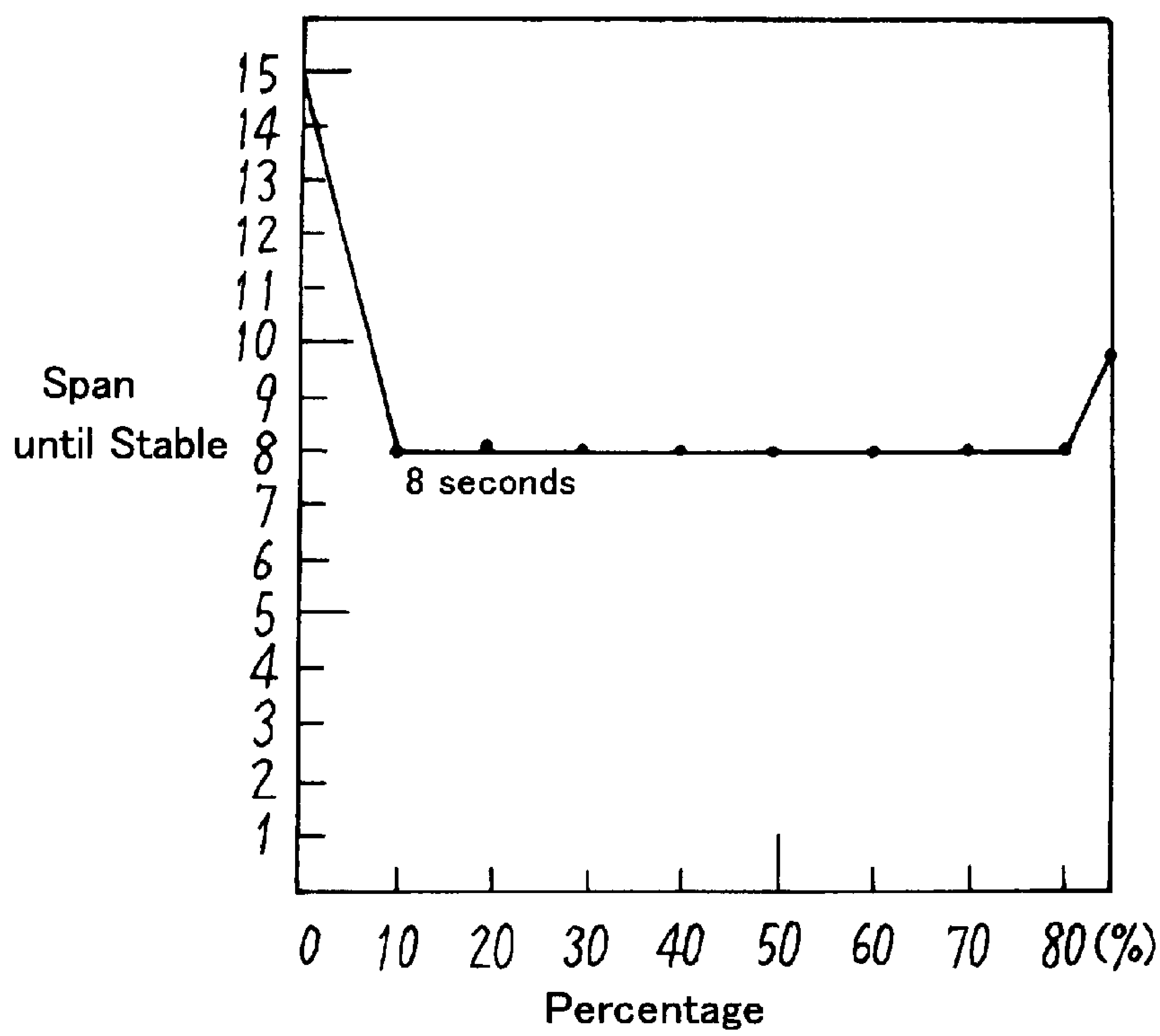

15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Span
until Stable
8 seconds
0
10
20
30
40
50
60
70
80(%)
Percentage

FIG. 18

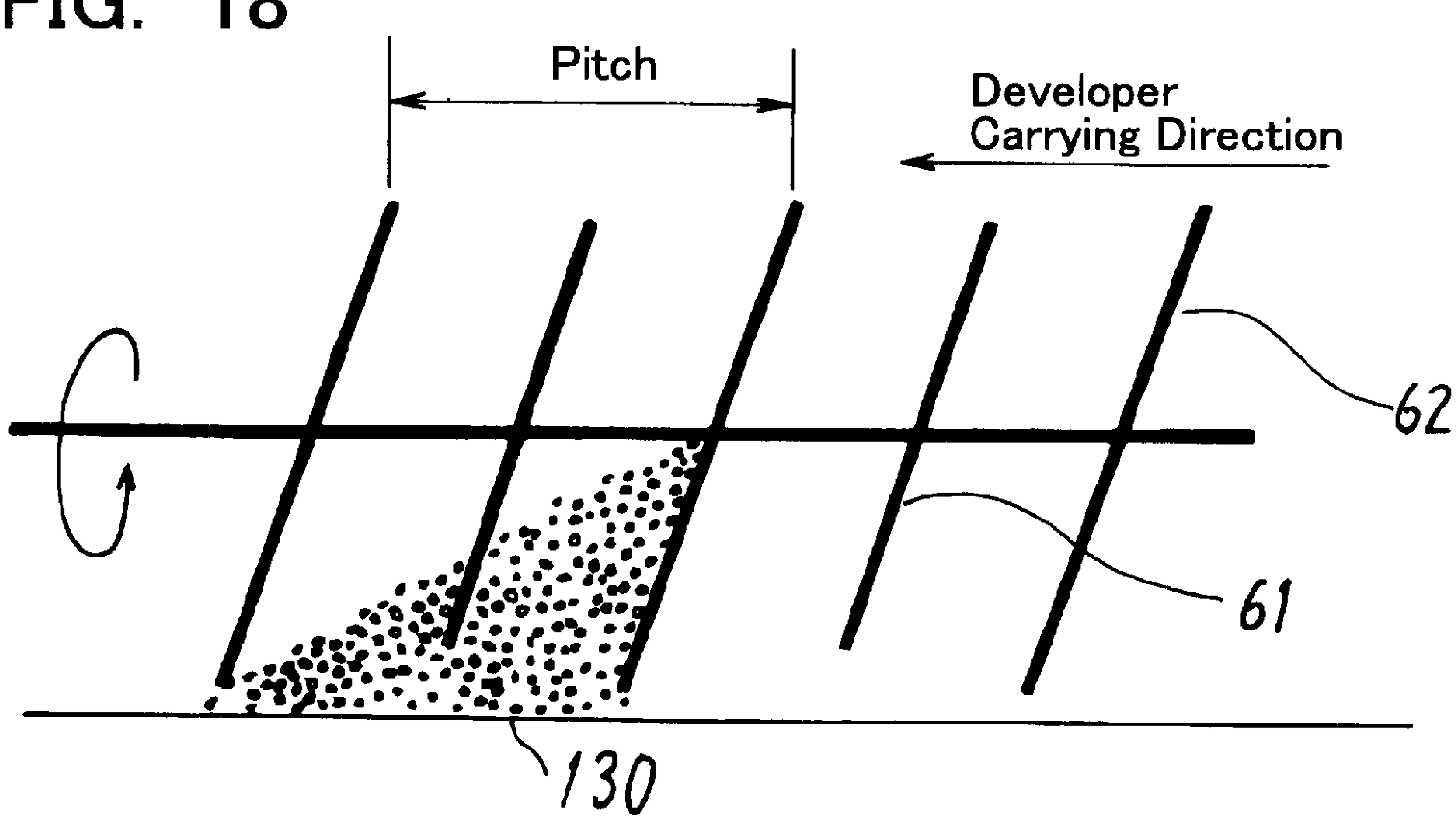

Pitch
Developer
Carrying Direction
62
61
130

FIG. 19

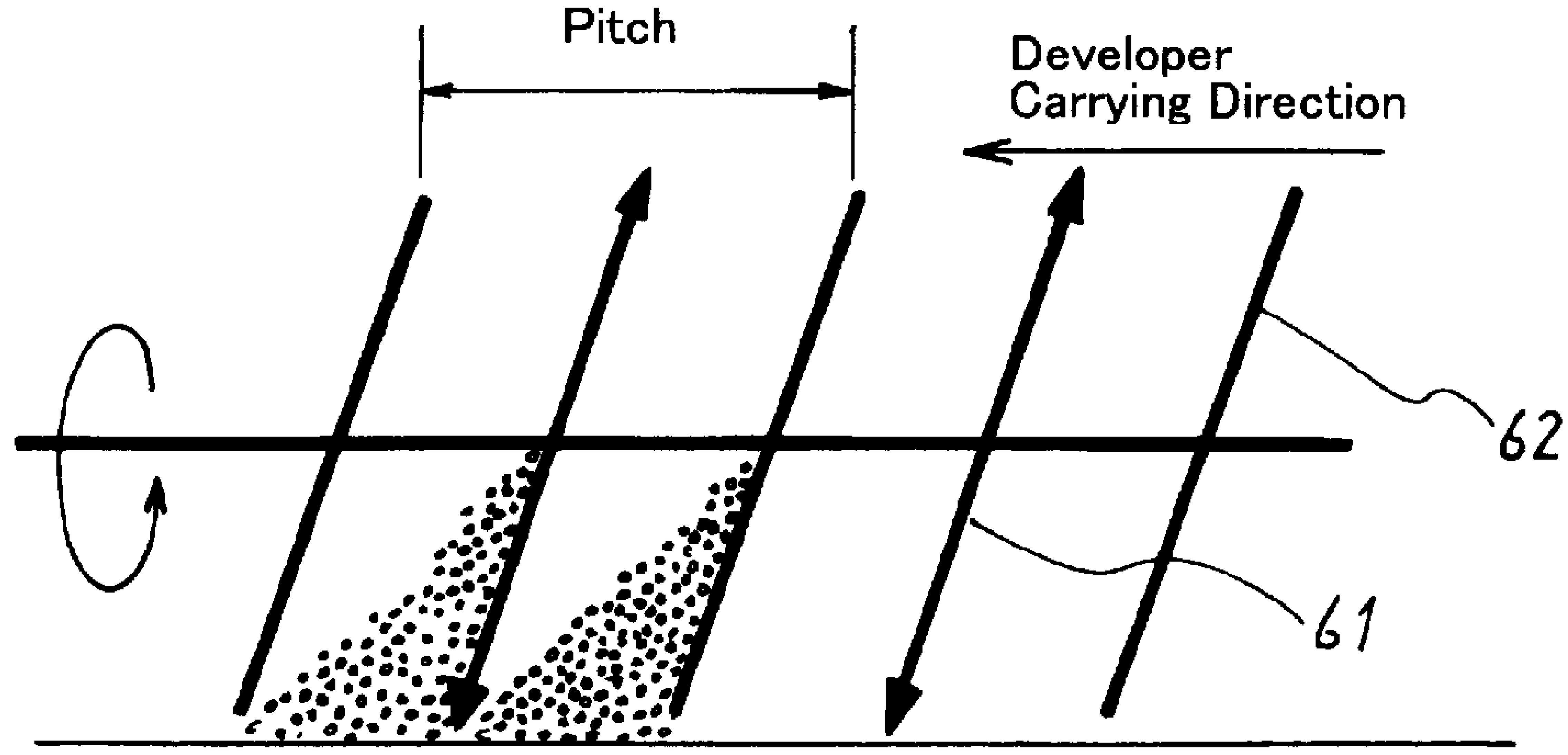

Pitch
Developer
Carrying Direction
62
61

FIG. 20

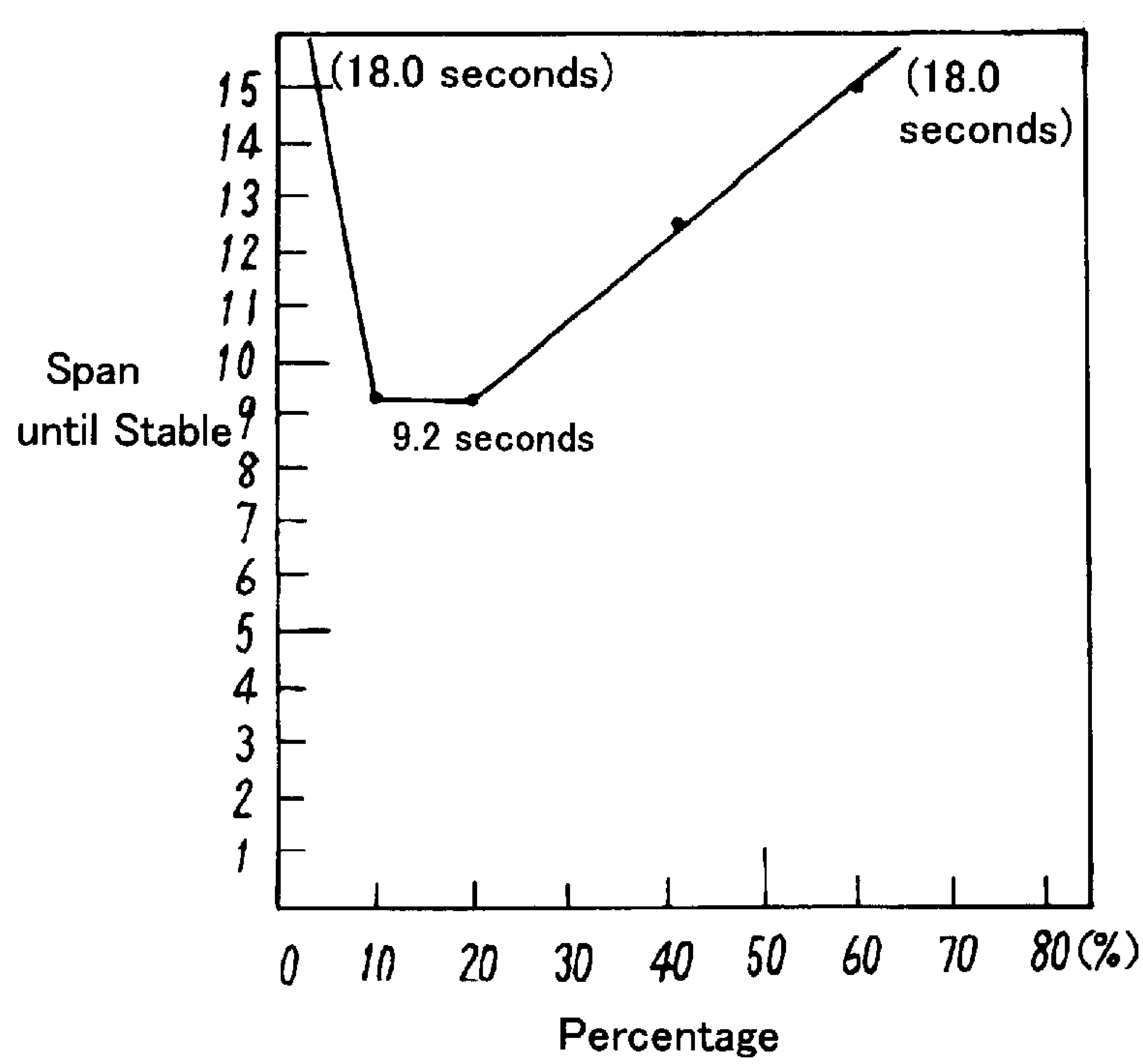

(18.0 seconds)
(18.0
seconds)
9.2 seconds
Span
until Stable
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
10
20
30
40
50
60
70
80(%)
Percentage

FIG. 21

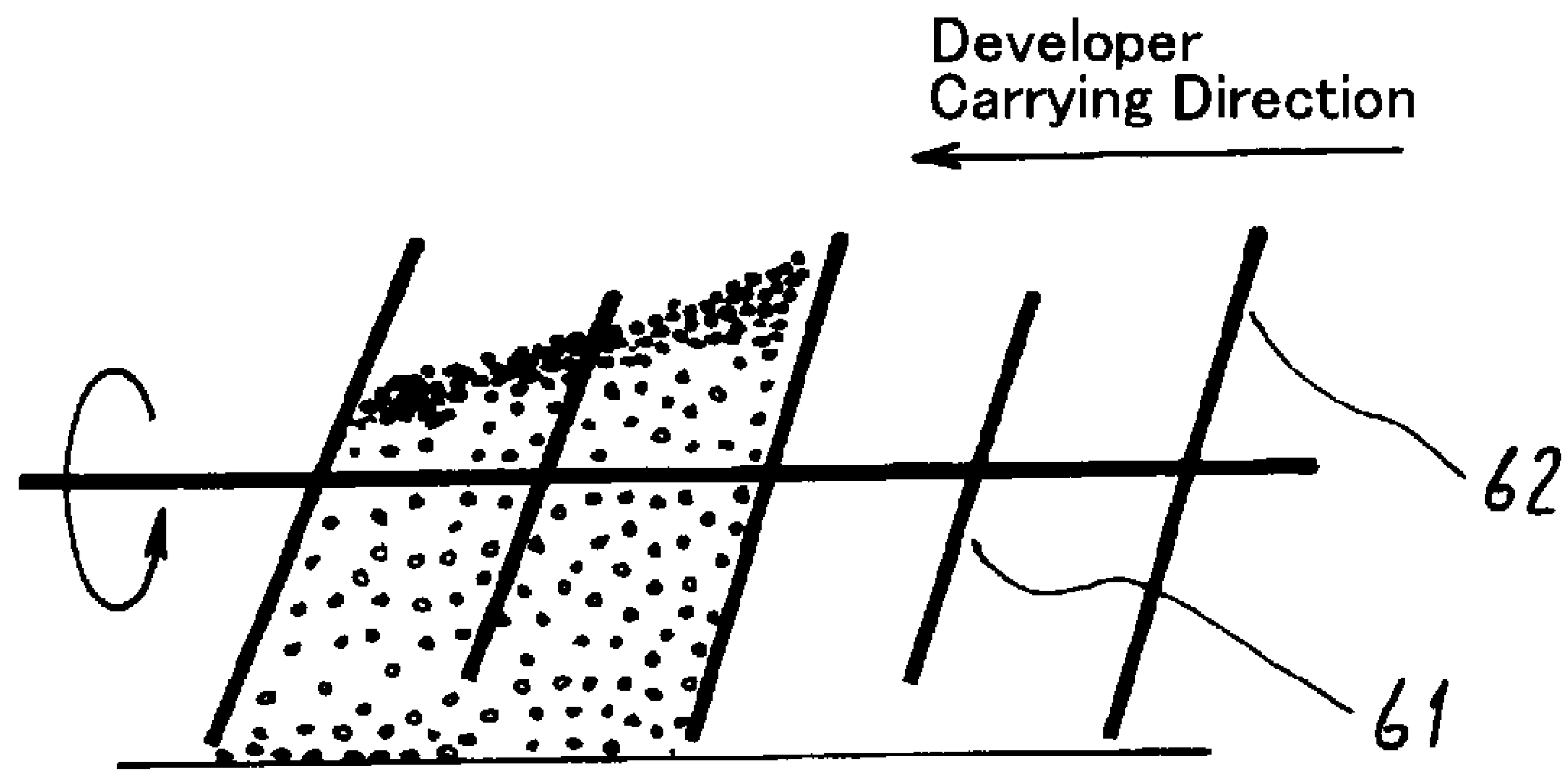


FIG. 22

Prior Art

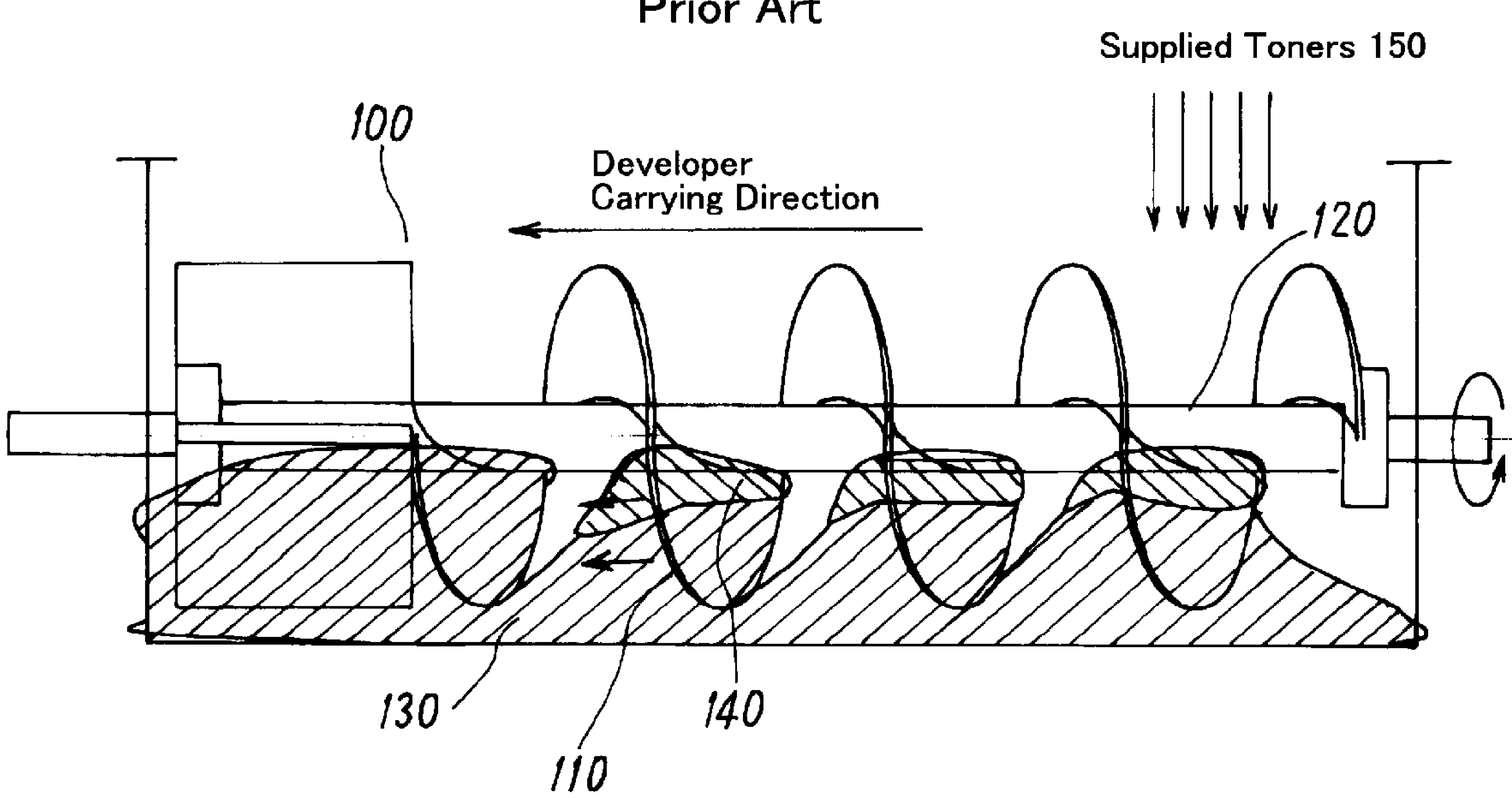


FIG. 23

Prior Art

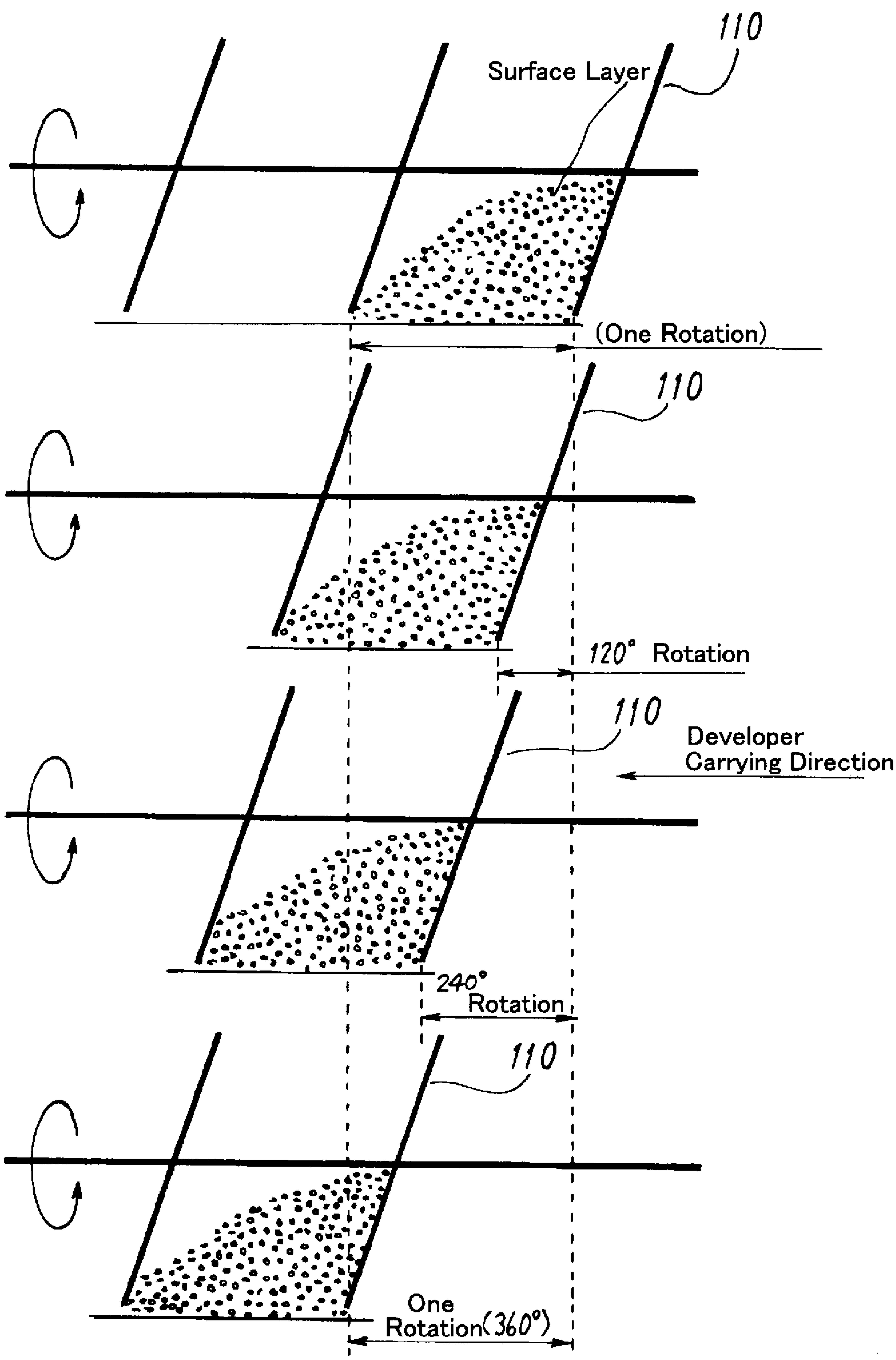
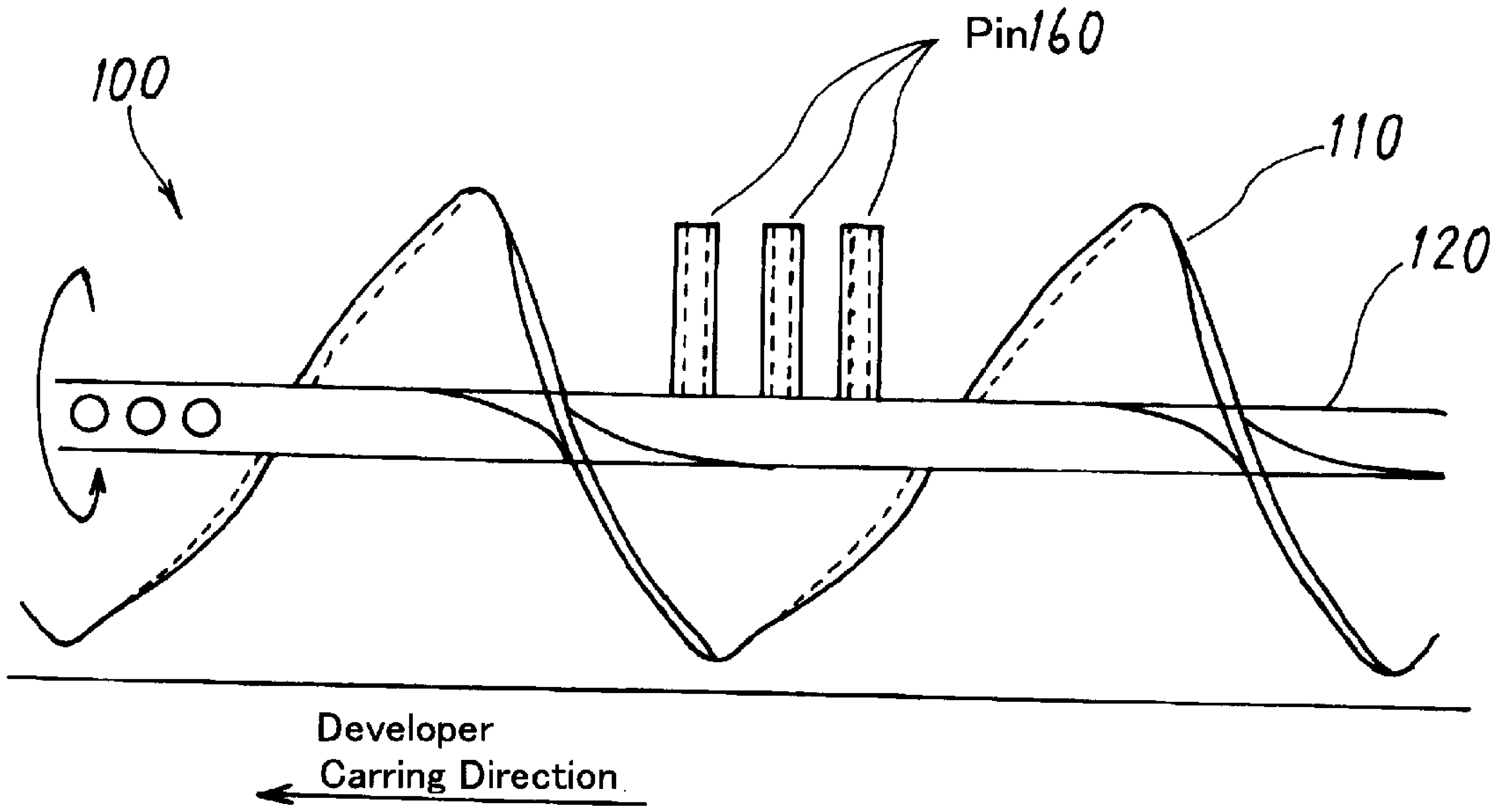


FIG. 24

Prior Art



TWO-COMPONENT DEVELOPING DEVICE, IMAGE FORMING APPARATUS, AND STIRRING SCREW THEREOF

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a two-component developing device, an image forming apparatus, and a stirring screw, which are used in an electrophotographic device, etc., and more particularly to a two-component developing device, an image forming apparatus, and a stirring screw, which are used for enhancing an efficiency of stirring two component developers to improve an image printing quality.

2. Description of the Related Art

Recently, the image forming apparatus used in the electrophotographic system has been widely used as an output device connected to a computer. This image forming apparatus has required a high-speed printing performance. Therefore, the developing device also has required a high performance appropriate for high-speed printing.

A general electrophotographic method used in an image forming apparatus comprises the following steps:

charging a photosensitive carrier with electricity;

exposing by light the photosensitive carrier to form a latent image thereon;

supplying developers to the photosensitive carrier to develop the latent image;

transferring a toner image on a medium; and

fixing the toners onto the medium.

In order to develop the latent image, a two-component developing device that uses toners and carriers is utilized. A toner concentration sensor is arranged in the two-component developing device, and this developing device performs to control the toner supply amount corresponds to the toner consumption for printing from a toner hopper. This is called a toner concentration control the two-component developing method enables the toners to be used by mixing and stirring the metallic-powder contained carriers with the resin toners to friction-charge these carriers and toners with electricity. Thus, a member for mixing and stirring these carriers and toners is arranged in the two-component developing device.

FIG. **22** is a constitutional view of a stirring screw in a conventional developing device, FIG. **23** is an explanatory view of the operation of the stirring screw, and FIG. **24** is a constitutional view of a stirring screw in another conventional developing device. As shown in FIG. **22**, a stirring screw **100** comprises a shaft **120** and a long-diameter spiral screw blade **110** wound around the shaft **120**. By rotating the screw **100**, the developer **130** is stirred and moved while being in friction-contact with the blade **110**. As shown in FIG. **23**, by rotating the screw **100**, the developer **130** is stirred-and moved while being in friction-contact with a single face of the blade **110**. In this process of stirring and moving the developer **130**, the supplied toners **150**, which are supplied from the toner hopper, can be stirred with the developer **130** containing the carriers and the toners, and can be also charged with electricity.

On the other hand, the high-speed printer requires a large toner consumption per hour, so both the toner supply count and the toner supply amount are increased. Therefore, as shown in FIG. **22**, when the stirring speed of the screw **100** is lower than the toner supply count or the toner supply amount, light-weight resin toners tend to collect upon an upper surface layer **140** of the developer **130** even by rotating the screw **100**. Such toners are not fully friction-charged with electricity, so they are uncharged. These uncharged toners are easily scattered and attach to other portions except the desired latent image to lower an image printing quality.

As shown in FIG. **24**, it is proposed that pins **160** should be arranged between the spiral blades **110** around the rotary shaft **120** to enhance the stirring ability. Using this constitution enables the developer **130**, which is carried by the spiral blade **110**, to be stirred even with the pins **160**, so the stirring ability is expected to be enhanced.

This image forming apparatus requires a high performance for high-speed printing. For example, the image forming apparatus needs to have the ability of printing **400** or more sheets per minute. When an image is formed at high speeds, not only the toner consumption per hour is increased but also the toner supply amount and the toner supply count are increased. Therefore, there is a problem that using the constitution in FIG. **24** enables the toners to be stirred in the positions of the pins **160** arranged, but not to be stirred between the pins **160**, so the high-speed printer cannot perform a sufficient stirring ability.

Furthermore, there is another problem that the developer **130** is subject to stress to shorten the developer's life because the pins **160** traverse the direction in which the blade **110** carries the developer **130**. For example, the coated layers of the carriers are subject to abrasion to easily lower the friction-charging ability.

SUMMARY OF THE INVENTION

It is an object of the present invention is to provide a two-component developing device, an image forming apparatus, and a stirring screw, for enhancing the stirring ability and forming an image at high speeds.

It is another object of the present invention to provide a two-component developing device, an image forming apparatus, and a stirring screw, for enhancing the stirring ability and lowering a stress exerted on the developer.

It is another object of the present invention to provide a two-component developing device, an image forming apparatus, and a stirring screw, for enhancing the stirring ability with an inexpensive constitution.

In order to this object, a two-component developing device of the present invention comprises a developer carrying member for carrying a developer containing carriers and toners, to a latent image carrier, and a stirring screw for stirring supplied toners with the developer. The stirring screw comprises a screw shaft, a spiral screw with a relatively short diameter, and another spiral screw with a relatively long diameter, wherein these two spiral screws are alternately wound around the same screw shaft.

According to the present invention, it is focused on the fact that the generation of uncharged toners due to the increased toner supply amount is caused by the event that toners are carried to the upper and lower surface layers of the developer with different concentrations, because a long-diameter spiral screw has a sufficient ability of carrying the entire developer, but does not have a sufficient ability of stirring the upper surface layer of the developer as described above. Thus, a fundamental conception of the present invention is to arrange a member for stirring the upper surface layer of the developer, between the long-diameter spiral screw blades.

The surface layer of the developer can be stirred even with the conventional rotary pins, but the rotary pins are in point-contact with the developer, have a low stirring ability, and traverse the direction in which the long-diameter spiral screw carries the developer. At the result, the developer tends to receive a stress and is deteriorated. When the number of pins is increased to enhance the stirring ability, this tendency causes the developer to receive more stress. However, according to the present invention, by arranging a short-diameter spiral screw as a member for stirring the surface layer of the developer, the developer can be stirred while being carried on the face of a short-diameter spiral screw blade. Therefore, the short-diameter spiral screw can fully stir the surface layer of the developer without exerting a stress on the developer, so that the generation of uncharged toners can be prevented and the high-speed image printing quality can be improved.

According to the present invention, the outer diameter of the short-diameter spiral screw blade is shorter 10% to 80% than that of the long-diameter spiral screw blade. Therefore, the surface layer of the developer can be stirred in a wide range of the developing device.

Furthermore, according to the present invention, the outer diameter of the short-diameter spiral screw blade is shorter 10% to 20% than that of the long-diameter spiral screw blade. Therefore, the surface layer of the developer can be fully stirred in a range of developer amount fluctuation limited within the developing device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a constitutional view of an image forming apparatus according to an embodiment of the present invention.

FIG. **2** is a constitutional view of a two-component developing device in FIG. **1**.

FIG. **3** is an enlarged view of the developing device in FIG. **2**.

FIG. **4** is a top plan view of the two-component developing device in FIG. **3**.

FIG. **5** is a constitutional view of a stirring screw according to an embodiment of the present invention.

FIG. **6** is a sectional view of the stirring screw in FIG. **5**.

FIG. **7** is an explanatory view of the operation of the stirring screw in FIG. **5**.

FIG. **8** is a sectional view of the operation of the stirring screw in FIG. **7**.

FIGS. **9**A, **9**B, **9**C, **9**D are transitional views of the developer's state, while the stirring screw in FIG. **5** is operated.

FIG. **10** is an explanatory view of the stirring effects to be obtained from the stirring screw in FIG. **5**.

FIG. **10**A is a top plan view of the stirring screw.

FIG. **10**B is a sectional view taken along the arrowed line A—A' of FIG. **10**A.

FIG. **10**C shows the case in which the stirring screw has no short-diameter spiral screw.

FIG. **11** is an explanatory view of the operation of the stirring screw of the developing device in FIG. **3**.

FIG. **12** is a sectional view of the stirring screw in FIG. **11**.

FIG. **13** is a constitutional view of the developing device for measuring the stirring effects to be obtained from the stirring screw according to an embodiment of the present invention.

FIG. **14** shows a waveform output by a toner concentration sensor.

FIG. **15** shows the relationship between the outer diameter of the short-diameter spiral screw and the stirring time, when the developer amount is set to the lower limit.

FIG. **16** is an explanatory view of the stirring operation, when the developer amount is set to the lower limit.

FIG. **17** shows the relationship between the outer diameter of the short-diameter spiral screw and the stirring time, when the developer amount is appropriate.

FIG. **18** is an explanatory view of the stirring operation of the stirring screw, when the developer amount is appropriate.

FIG. **19** is an explanatory view of the stirring operation of another stirring screw as an example to be compared.

FIG. **20** shows the relationship between the outer diameter of the short-diameter spiral screw and the stirring time, when the developer amount is set to the upper limit.

FIG. **21** is an explanatory view of the stirring operation, when the developer amount is set to the upper limit.

FIG. **22** is an explanatory view of a conventional stirring screw.

FIG. **23** is an explanatory view of the stirring operation of the conventional stirring screw.

FIG. **24** is an explanatory view of another conventional stirring screw.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As the preferred embodiments of the present invention, an image forming apparatus, a stirring screw, and other embodiments are explained below with reference to the drawings as attached.

[Image Forming Apparatus]

Referring to the attached drawings, FIG. **1** is a constitutional view of an image forming apparatus as an embodiment of the present invention, FIG. **2** is a constitutional view of a two-component developing device in the image forming apparatus, FIG. **3** is an enlarged view of the developing device body in FIG. **2**, and FIG. **4** is a top plan view of the two-component developing device in FIG. **2**.

FIG. **1** shows an example of an image forming apparatus used in a printer **10** comprising an electrophotographic mechanism. After a charger **20** charges a photosensitive drum **12** with electricity, a laser exposure device **22** exposes by lighting an image on the photosensitive drum **12** to form a latent image thereon. A two-component developing device body **14** carries a two-component developer to the photosensitive drum **12** to develop the latent image into a toner image. A transfer device **16** transfers the toner image on the photosensitive drum **12**, to a sheet **25**. After the toner image is transferred to the sheet **25**, a cleaning mechanism **18** discharges the electricity from the photosensitive drum **12** and removes the residual toners therefrom.

The sheet **25** is a continuous paper stacked in a hopper **24**. The sheet **25** stacked in the hopper **24** is fed to a transfer position to which the toner image is transferred, and then accommodated in a stacker **26** after passing through a flash fixing device **36**. The flash fixing device **36** fixes the toner image onto the sheet **25**, using the optical energy of flashes.

The printer **10** can execute a high-speed printing, which enables 40,000 or more lines to be printed per minute. Therefore, the printer **10** sublimates a large amount of toners during the flash fixing process. To remove this sublimated component, a filter **32** and a ventilating fan **38** are arranged in the printer **10**.

An inorganic-sensitized body such as amorphous silicone, selenium, etc., and an organic-sensitized body such as polysilane, phthalocyanine, etc. can be used as photosensitive bodies. Particularly, the amorphous silicone sensitized bodies are favorably used, viewing from the "long life thereof."

Referring to FIG. **2**, the two-component developing device **14** comprises a developing device body **14** and a toner hopper **34**. An unshown toner bottle fills the toners into the toner hopper **34**. Depending on the toner concentration detected by an unshown toner concentration sensor in the developing device body **14**, the toner hopper **34** supplies the toners to the developing device body **14** so as to keep the toner concentration constant in the developing device body **14**.

Referring to FIGS. **2** and **3**, the two-component developing device body **14** comprises three developing magnet rolls **1**, **2**, and **3**. Each of the developing magnet rolls **1**, **2**, and **3** carries a two-component developer containing carriers and toners to the photosensitive drum **12** so as to develop the latent image on the photosensitive drum **12** in to a toner image. This developing device body **14** has the developing area three times as large as that of the conventional developing device, so the latent image on the photosensitive drum **12** can be developed satisfactorily into the toner image even when the photosensitive drum **12** is rotated at high speeds for high-speed printing.

A carrying conveyor magnet roll **4** is arranged under a first developing magnet roll **1**. The carrying conveyor magnet roll **4** carries the developer in the developing device body **14** to the first developing magnet roll **1**. A carrying screw **5** is arranged beside the carrying conveyor magnet roll **4**. The developer is returned to the stirring screw **5** from the third developing magnet roll **3** through a guide **9**, the stirring screw **5** carries the developer in one direction by rotating in the direction opposite to the carrying conveyor magnet roll **4**.

A stirring and carrying screw **6** is rotated in the direction opposite to the carrying screw **5** to carry the developer in the opposite direction. A partition plate **8** is arranged between the carrying screw **5** and the stirring and carrying screw **6** so as to circulate the developer through the developing device body **14** by rotating the carrying screw **5** and the stirring and carrying screw **6**. A pair of paddles **7** stir and loosen the toners to be supplied from a toner supply port of the toner hopper **34**, and carry the supplied toners to the stirring and carrying screw **6**.

Therefore, the developer is supplied to the first developing magnet roll **1** through the carrying conveyor magnet roll **4**, and carried from the first developing magnet roll **1** to the second and third developing magnet rolls **2** and **3**, and returned to the carrying screw **5** through the guide **9**.

Referring to FIG. **4**, the supplied toners from the toner hopper **34** are supplied to and stirred by the stirring paddles **7**, and then carried to the stirring and carrying screw **6**. The stirring and carrying screw **6** stirs the toners with the developer carried from the carrying screw **5** through an end of the partition plate **8**, and returns the developer to the carrying screw **5** from the other end of the partition plate **8** to circulate the developer through the developing device body **14**.

The toner supply port of the toner hopper **34** has a relatively wide opening, the size of which is smaller than the width of the developing device body **14** so as to prevent the lumps of toners from being supplied. Therefore, the toners supplied from the toner hopper **34** to the downstream side in the developer carrying direction of the developing device body **14** cannot be fully stirred because of the short stirring distance of the stirring and carrying screw **6**.

[Stirring Screw]

FIG. **5** is a constitutional view of a stirring and carrying screw **6** as an embodiment of the present invention, FIG. **6** is a sectional view of the stirring and carrying screw **6**, and FIGS. **7** to **10** are explanatory views of the operations of the stirring and carrying screw **6**.

Referring to FIG. **5**, the stirring and carrying screw **6** comprises a rotary shaft **60**, a spiral screw **62** with a relatively long diameter, and another spiral screw **61** with a relatively short diameter. The spiral screws **61** and **62** are alternately wound around the rotary shaft **60**. For example, the outer diameter of a long-diameter spiral screw blade **62** is 72 mm, and that of a short-diameter spiral screw blade **61** is 56 mm, and the screw pitch is 53 mm. The paddles are indicated by reference number **63**.

Referring to FIG. **6**, the relationship between a developer **130** and both the short-diameter spiral screw **61** and the long-diameter spiral screw **62** is shown by the sectional view thereof. In other words, the long-diameter spiral screw **62** has a sufficient diameter to stir the entire developer **130**, and the short-diameter spiral screw **61** has a sufficient diameter to stir a part ⌈A⌋ around the rotary shaft **60**, where the supplied toners relatively tend to collect (i.e., the upper part where the developer collects).

Referring to FIGS. **7** to **10**, the operations of the spiral screws **61** and **62** are explanatorily shown. FIG. **7** shows the state of developer **130** when the stirring and carrying screw **6** is rotated, FIG. **8** is a sectional view of the operation of the stirring and carrying screw **6**, and FIGS. **9**A, B, C, and D show the transition of the developer's states when the stirring and carrying screw **6** is rotated by 120, 240, and 360 degrees.

Referring to FIG. **8**, the developer **130** is positioned slantwise between the blades of the long-diameter spiral screw **62**, by rotating the long-diameter spiral screw **62**, viewing from the sectional view thereof, and a space ① is formed on the back of the next blade of the long-diameter spiral screw **62**. As shown in FIGS. **7** and **8**, the surface layer ② of the developer **130**, which is formed by a blade of the long-diameter spiral screw **62**, is carried to the space ① on the back of the next blade of the spiral long-diameter screw **62**, while being loosened by a blade of a short-diameter spiral screw blade **61**. After the blade of the short-diameter spiral screw **61** loosens the surface layer **(2)** of the developer **130**, the next blade of the long-diameter spiral screw **62** stirs and carries the entire developer **130**.

By repeatedly executing this operation, the entire developer **130** can be fully stirred. In FIGS. **9**A, **9**B, **9**C and **9**D, the transition of the developer's states are shown, the spiral long-diameter screw **62** stirs and carries the developer **130**, while the surface layer ② of the developer **130** are loosened by the blades of the short-diameter spiral screw **61** that are arranged between the blades of the long-diameter spiral screw **62**.

The spiral screw **61** has a short diameter, so a space is formed between the bottom of the developing device body **14** and the blade of the short-diameter spiral screw **61**. Therefore, the blades of the short-diameter spiral screw **61** come into contact with a heap of the developer **130**, which is formed by the blades of the long-diameter spiral screw **62**, on the upstream and downstream sides in the developer carrying direction, so that the surface layer ② of the developer **130** can be stirred by rotating the carrying screw **61**. The short-diameter spiral screw **61** is extended spirally around the rotary shaft **60**, so the developer **130** can be stirred while being carried. Therefore, the short-diameter spiral screw **61** can fully stir the surface layer ② of the developer **130** without exerting a stress on the developer **130**, so that the generation of uncharged toners can be prevented and the high-speed image printing quality can be improved.

Referring to FIG. **10**A as the top plan view of the stirring and carrying screw **6** and FIG. **10**B as the sectional view thereof, the surface layer ② of the developer **130** is carried while getting over the rotary shaft **60**, by rotating the short-diameter spiral screw **61**. This operation enables the efficiency of stirring the developer **130** to be further enhanced. The short-diameter spiral screw **61** enables the efficiency of stirring the developer **130** to be further enhanced without changing the developer carrying speed of the long-diameter spiral screw **62**. On the other hand, referring to FIG. **10**C, the surface layer ② of the developer **130** is not stirred by rotating only the long-diameter spiral screw **62**.

FIG. **11** is the top plan view of the stirring and carrying screw **6** and FIG. **12** is the sectional view thereof, when the stirring and carrying screw **6** is used in the developing device body **14** with the constitutions in FIGS. **2** to **4**. Referring to FIGS. **11** and **12**, the supplied toners from the toner hopper **34** is supplied to and stirred by the stirring paddles **7**, and then carried to the stirring and carrying screw **6**. The stirring and carrying screw **6** stirs the toners with the developer **130** carried from a carrying screw **5** through a receiving and sending paddle **50** positioned at an end of the partition plate **8**, and returns the developer **130** from a receiving and sending paddle **63** positioned at the other end of the partition plate **8**, to the carrying screw **5** to circulate the developer **130**.

The stirring and carrying screw **6** carries and stirs the developer **130** by rotating the long-diameter spiral screw **62** and the short-diameter spiral screw **61** thereof, so that it can stir the supplied toners with the developer **130** without exerting a stress on the developer **130**. Therefore, as shown in FIG. **4**, in the case that the toner supply port of the toner hopper **34** is smaller than the width of the developing device body **14**, but has a relatively wide opening, to prevent the lumps of toners from being supplied, the toners supplied from the toner hopper **34** to the downstream side in the developer carrying direction of the developing device body **14** can be fully stirred even when the stirring distance of the stirring and carrying screw **6** is short.

Therefore, this developing device can prevent the generation of uncharged toners and improve the quality of the formed image, even when a large amount of toners are consumed and frequently supplied for high-speed printing.

Then, the following explains the relationship in length between the outer diameters of a short-diameter spiral screw blade **61** and a long-diameter spiral screw blade **62**. In other words, it is discussed below whether the stirring effect can be improved when the outer diameter of the short-diameter spiral screw blade **61** is shortened by what percent of that of the long-diameter spiral screw blade **62**.

The range of values to be set as the outer diameter of the short-diameter spiral screw blade **61** is determined between the lower limit of decreasing the developer amount and the upper limit of increasing the developer amount in the developing device body **14**. At this time, the percent of shortening the outer diameter of the short-diameter spiral screw blade **61** is calculated by using (Long-diameter spiral screw blade's outer diameter)−(Screw shaft's diameter)= 100% as the reference expression. The lower limit of decreasing the developer amount indicates the state in which the developer **130** is irregularly supplied onto the developing magnet rolls **1** to **3**. On the other hand, the upper limit of increasing the developer amount indicates the state in which the top of the outer diameter of the long-diameter spiral screw blade **62** reaches the surface level of the developer **130**. When the surface level of the developer **130** exceeds the top of the outer diameter of the long-diameter spiral screw blade **62**, the stirring and carrying screw **6** does not carry the developer volume existing between the surface level of the developer **130** and the top of the outer diameter of the long-diameter spiral screw blade **62**.

Then, a test was made under the following conditions to set the outer diameter of the short-diameter spiral screw blade **61**, using the developing device body **14** for a high-speed printer consuming a developer of 7.0 kg, as shown in FIG. **3**:

[Conditions for the Developing Device Body]

Number of rotations of the stirring and carrying screw **6**: 250 rpm

Outer diameter of the long-diameter spiral screw blade **62**: ϕ72 mm

Number of rotations of the carrying screw **5**: 250 rpm

Outer diameter of the carrying screw blade **5**: ϕ72 mm

Number of rotations of the stirring paddle **50** or **63**: 120 rpm

Number of rotations of the carrying conveyor magnet roll **4**: 193 rpm

Developer/Toner concentration: 4.5 Wt %

Number of rotations of the developing magnet rolls **1** to **3**: 550 rpm

Developing blade gap: 0.4 mm

Referring to FIG. **13**, the stirring effect of the short-diameter spiral screw **61** of the stirring and carrying screw **6** combined the long and short diameter spiral screws to same shaft was confirmed, depending on the waveform output from a toner concentration sensor **90** (Toner concentration sensor=Tc sensor). The sensor **90** is arranged in a screw case (bottom plate) of the developing device body **14** for the normal toner concentration control.

As shown in FIG. **13**, the stirring effect was confirmed by circulating the developer **130** through the developing device body **14** with only the screws **5** and **6** therein to supply the toners from the upstream side in the developer carrying direction thereof to a position "B" before the toner concentration sensor **90**, and by monitoring the waveform output therefrom. However, the amount of toners that can be supplied at one time is 17 g.

The waveform output from the sensor **90** is large in the range of high toner concentrations, but it is stable and low when the toner concentration becomes constant by stirring the toners. At this time, the waveform was monitored with a pen recorder. Referring to FIG. **14**, the stirring effect was determined by the time span (seconds) between when the sensor output waveform was large by supplying the toners to the position "B" before the toner concentration sensor **90** and when the toner concentration became constant by fully stirring the toners and the output waveform became stable. In other words, when it takes a short time for a large waveform to change to a small one, a good stirring effect can be obtained, but when it takes a long time, no sufficient effect can be obtained. In this case, it was determined whether the toner output condition was stable when the waveform was output with a voltage of 0.1V or less applied.

FIG. **15** shows the relationship between the percent (%) of shortening the short-diameter spiral screw blade's outer diameter (i.e., the percent of setting the short-diameter spiral screw blade's outer diameter shorter than the long-diameter spiral screw blade's) and the result of measuring the time (seconds) of which the output of the Tc sensor **90** is stable, when the developer amount is set to 4.0 kg as the lower limit.

FIG. **16** is an explanatory view of the operations of the short-diameter and long-diameter spiral screws.

As shown in the measuring result from FIG. **15**, when the short-diameter spiral screw is rotated at the lower limit of decreasing the developer amount with the percent of shortening the outer diameter thereof shortened by 10% to 35% of the long-diameter spiral screw blade's outer diameter, the waveform output from the toner concentration sensor **90** becomes stable 7.3 seconds after the toners supplied. On the contrary, when the short-diameter spiral screw is rotated with the percent of shortening the outer diameter thereof shortened by less than 10% or over 35% of the long-diameter spiral screw blade's outer diameter, the stirring ability is lowered because it takes a long time for the sensor output waveform to be stable.

At the result, a sufficient stirring effect can be obtained when the developer amount is decreased to 4.0 kg as the lower limit, with the percent of shortening the short-diameter spiral screw blade's outer diameter by 10% to 35% of the long-diameter spiral screw blade's. As shown in FIG. **16**, no sufficient stirring effect can be obtained, when the percent of shortening the outer diameter of the short-diameter spiral screw blade **61** is less than 10% of that of the long-diameter spiral screw blade **62** and the outer diameter of the screw blade **61** approximates to that of the screw blade **62**. Because the developing device body enters the state where a short-diameter spiral screw does not exist and a further long-diameter spiral screw is arranged between the spiral screw **62**.

When the short-diameter spiral screw is rotated with the percent of shortening the outer diameter thereof by over 35% of the long-diameter spiral screw blade's outer diameter, no stirring effect can be obtained because the short-diameter spiral screw blades **61** have a few (or no) contacts with the developer **130**.

FIG. **17** shows the relationship between the percent (%) of shortening the short-diameter spiral screw blade's outer diameter (i.e., the percent of setting the short-diameter spiral screw blade's outer diameter shorter than the long-diameter spiral screw blade's) and the result of measuring the time (seconds) of which the output of the Tc sensor **90** is stable, when the developer amount is set to 7.0 kg as an appropriate amount. FIGS. **18** and **19** show the operations of the short-diameter and long-diameter spiral screws.

The result from FIG. **17** indicates that the sensor output waveform becomes stable 8.0 seconds after the toners supplied, when the developer amount is set to 7.0 kg as an appropriate amount with the percent of shortening the short-diameter spiral screw blade's outer diameter by 10% to 80% of the long-diameter spiral screw blade's. In other words, when the developer amount is set to 7.0 kg, there is a wide range of 10% to 80%, between which the short-diameter spiral screw blade s outer diameter can be set shorter than the long-diameter spiral screw blade's to obtain a sufficient stirring effect. However, when the short-diameter spiral screw blade's outer diameter is shortened by less than 10% or over 80% of the long-diameter spiral screw blade's, the stirring ability is lowered.

Referring to FIG. **18**, the margin line (surface) of the developer **130** corresponds with the position of the screw shaft, and there is a wide range of is 10% to 80%, to which the short-diameter spiral screw blade's outer diameter can be set shorter than the long-diameter spiral screw blade's to obtain a sufficient stirring effect. On the contrary, as shown in FIG. **19**, no stirring effect can be obtained, when the short-diameter spiral screw outer diameter is shortened by less than 10% of the long-diameter spiral screw blade's. Because the developing device body enters the state where the outer diameter of the short-diameter spiral screw blade **61** approaches to that of the long-diameter spiral screw blade **62**, a short-diameter spiral screw does not exist, and a long-diameter spiral screw is further arranged between the spiral screw **62**.

Furthermore, when the short-diameter spiral screw blade's outer diameter is shortened by over 80% of the long-diameter spiral screw blade's, no stirring effect can be obtained because the developer cannot be fully stirred. This is because a portion of the short-diameter spiral screw blade is not projected highly upward from the screw shaft.

FIG. **20** shows the relationship between the percent (%) of shortening the short-diameter spiral screw blade's outer diameter (i.e., the percent of setting the short-diameter spiral screw blade's outer diameter shorter than the long-diameter spiral screw blade's) and the result of measuring the time (seconds) of which the output of the Tc sensor **90** is stable, when the developer amount is set to 10.0 kg as the upper limit. FIG. **21** shows the operations of the short-diameter and long-diameter spiral screws.

The measuring result of FIG. **20** indicates that when the developer amount is increased up to the upper limit, there is a narrow range of shortening the short-diameter spiral screw blade's outer diameter by 10% to 20% of the long-diameter spiral screw blade's to obtain a sufficient stirring effect. However, the stirring ability is lowered when the short-diameter spiral screw blade's outer diameter is shortened by less than 10% or over 20% of the long-diameter spiral screw blade's. As shown in FIG. **21**, when the developer amount is increased up to 10 kg as the upper limit, the margin line (surface) of the developer **130** reaches the top of the spiral long-diameter screw blade's outer diameter. Thus, a sufficient stirring effect can be obtained when the short-diameter spiral screw blade's outer diameter is shortened by 10% to 20% of the long-diameter spiral screw blade's.

On the contrary, when the short-diameter spiral screw blade's outer diameter is shortened by less than 10% of the spiral long-diameter screw blade's, no stirring effect can be obtained because the short-diameter spiral screw blade's outer diameter approximates to the long-diameter spiral screw blade's, and a short-diameter spiral screw does not exist. As shown in FIG. **21**, when the short-diameter spiral screw blade's outer diameter is shortened by over 20% of the long-diameter spiral screw blade's, the margin line (surface) of the developer **130** is on a high level. Therefore, the short-diameter spiral screw **61** is put under the developer **130** and cannot stir the surface layer ② of the developer **130** with a high toner concentration. At the result, the short-diameter spiral screw **61** cannot fully stir the developer **130**.

It can be judged from the above-described results that a sufficient stirring effect can be obtained when the outer diameter of the short-diameter spiral screw blade **61** is shortened by 10% to 80% of that of the long-diameter spiral screw blade **62**. Particularly, when the developer amount is set to an appropriate amount, this range of 10% to 80% is effective. In addition, a sufficient stirring effect can be obtained for the entire developer amount, when the developer amount is set in the range between the upper and lower limits and the outer diameter of the short-diameter spiral screw blade **61** is shortened by 10% to 20% of that of the long-diameter spiral screw blade **62**.

[Other Embodiments]

In addition to the above-described embodiments, the following modifications are made in the present invention:

(1) A printer is cited as an example of an image forming apparatus to explain the above-described embodiments of

the present invention, but these embodiments can be applied to other image forming apparatus such as a copier and facsimile equipment except the printer.

(2) The two-component developing device for the high-speed printer in FIG. **3** is cited as an example to explain the two-component developing device, but this embodiment can be applied to other two-component developing devices.

(3) A carrying screw **5** arranged in the developing device body can be constituted of a stirring and carrying screw **6**.

As explained above, the following effects can be expected according to the present invention:

(1) By arranging a short-diameter spiral screw as a member for stirring the surface layer of the developer on a long-diameter spiral screw, the developer can be stirred while being carried on the face of a short-diameter spiral screw blade. Therefore, the short-diameter spiral screw can fully stir the surface layer of the developer without exerting a stress on the developer.

(2) The short-diameter spiral screw enables the generation of uncharged toners to be prevented and the high-speed image printing quality to be improved, even when both the toner supply amount and the toner supply count are increased for high-speed printing.

It is further understood by those skilled in the art that the foregoing descriptions are preferred embodiments of the disclosed invention and that various changes and modifications may be made in the invention without departing from the spirit and scope thereof.

What is claimed is:

1. A two-component developing device for developing a latent image on a latent image body, comprising:

a developing carrying member for carrying a developer containing carriers and toners, to the latent image body; and

a stirring screw for stirring supplied toners with the developer;

wherein said stirring screw comprises;

a screw shaft;

a short-diameter spiral screw blade with a relatively short diameter; and

a long-diameter spiral screw blade with a relatively long diameter, which are alternately wound around the same screw shaft;

wherein both spiral directions of said short-diameter spiral blade and said long-diameter spiral blade are the same so as to convey said two-component developer to a same direction.

2. The two-component developing device according to claim **1**,

wherein an outer diameter of the short-diameter spiral screw blade is in a range from 10% to 80% shorter than that of the long-diameter spiral screw blade.

3. The two-component developing device according to claim **2**,

wherein the outer diameter of the short-diameter spiral screw blade is in a range from 10% to 20% shorter than that of the long-diameter spiral screw blade.

4. The two-component developing device according to claim **1**, further comprising;

a toner hopper for supplying toners to the stirring screw.

5. The two-component developing device according to claim **1**, wherein the carrying member for carrying the developer in a direction opposite to a developer carrying direction of the stirring screw; and

wherein the carrying member is arranged parallel to the stirring screw.

6. An image forming apparatus, comprising:

a latent image body;

a latent image forming unit for forming a latent image on the latent image body;

a two-component developing device for developing the latent image on the latent image body; and

a transfer device for transferring the developed image on the latent image body, to a medium;

wherein said two-component developing device comprises;

a developer carrying member for carrying a developer containing carriers and toners, to the latent image body; and

a stirring screw for stirring supplied toners with the developer and comprises a screw shaft, a short-diameter spiral screw blade with a relatively short diameter, and a long-diameter spiral screw blade with a relatively long diameter, which are alternately wound around the same screw shaft;

wherein both spiral directions of said short-diameter spiral blade and said long-diameter spiral blade are the same so as to convey said two-component developer to a same direction.

7. The image forming apparatus according to claim **6**, wherein an outer diameter of a short-diameter spiral screw blade is in a range from 10% to 80% shorter than that of a long-diameter spiral screw blade.

8. The image forming apparatus according to claim **6**, wherein the outer diameter of the short-diameter spiral screw blade is in a range from 10% to 20% shorter than that of the long-diameter spiral screw blade.

9. The image forming apparatus according to claim **6** further comprising;

a toner hopper for supplying the toners to the stirring screw.

10. The image forming apparatus according to claim **6**, wherein:

a carrying screw for carrying the developer in a direction opposite to a developer carrying direction of the stirring screw;

wherein the carrying screw is arranged in parallel to the stirring screw.

11. A stirring screw used in a two-component developing device for stirring supplied toners with two-component developer, comprising;

a screw shaft;

a short-diameter spiral screw blade with a relatively short diameter; and

a long diameter spiral screw blade with a relatively long diameter, which are alternately wound around the same screw shaft;

wherein both spiral directions of said short-diameter spiral blade and said long-diameter spiral blade are the same so as to convey said two-component developer to a same direction.

12. The stirring screw according to claim **11**, wherein an outer diameter of a short-diameter spiral screw blade is in a range from 10% to 80% shorter than that of a long-diameter spiral screw blade.

13. The stirring screw according to claim **11**, wherein the outer diameter of the short-diameter spiral screw blade is in a range from 10% to 20% shorter than that of the long-diameter spiral screw blade.

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